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JUNE, 1937.

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To
The King's
Most Excellent Majesty

May it please your Majesty

We, the Members of The Institution of Production Engineers, humbly tender to Your Majesty our Loyal Greetings and Congratulations on the historic occasion of Your Majesty's Coronation.

We are deeply sensible of the great interest which Your Majesty has always shown not only in industrial welfare questions but in manufacturing processes and methods, and feel assured that Your Majesty's good wishes and encouragement will continue to be with those who, in their daily work and with the co-operation of scientific bodies such as this Institution, must bear their share of responsibility for increasing and improving production within Your Majesty's Realm.

Our earnest prayer is that many long years of honour and happiness may lie before Your Majesty and Queen Elizabeth, and that Your Reign may mark a period of greatness and progress unrivalled in the annals of our history.

Signed on behalf of the Institution

Sampson — President

Chairman of Council

General Secretary

London,
May, 1937.

11th June, 1937.

My Lord,

I have had the honour to lay before The King the loyal and dutiful Address of the Institution of Production Engineers on the occasion of Their Majesties' Coronation, and I have been commanded by The King to convey to Your Lordship, as President of the Institution, Their Majesties' warm thanks for the expressions of loyalty and devotion which it contains.

I have the honour to be,

My Lord,

Your Lordship's obedient Servant,

Samuel Hoare

The Lord Sempill, A.F.C.

The Home Secretary's reply, on behalf of His Majesty, to the Address presented to H.M. the King by the Institution on the occasion of Their Majesties' Coronation. The Address, 19¼ x 12¼ *(as well as the reproduction facing this page) was printed by the Institution's Printing Department.*

DEVELOPMENTS IN MACHINE TOOLS

Paper presented to the Institution, London and Leicester Sections, by I. H. Wright, M.I.P.E., M.I.Mech.E.

THE title of my paper to-night, as announced in the winter's programme, is " Developments in Machine Tools," and this is I believe, a subject of interest to the great majority of production engineers, as an examination of recent programmes reveals that many papers on machine tool construction subjects have been presented.

Before going into detail, I should like to discuss briefly my conception of the meaning of the word " development." According to my idea, it means what has been done recently to improve machine tools in any way and what we are even now doing to that end. Whether the present-day developments will turn out to be progress or not, is quite another matter, as progress, though based on, and consisting of developments, is only measurable by a comparison of the state of machine construction to-day with its state at some previous period.

Put another way, development consists of the efforts of both machine-tool makers and machine-tool users to improve the machines, whilst progress represents the success of their efforts, and is measured by the more or less general acceptance and use of the machines so improved.

As an example, the modern motor car, compared with a very early model, represents progress, but it only represents a small proportion of the developments which have from time to time occupied the time and attention of both makers and users, and, during this time, enormous numbers of developments each in its time giving considerable promise have been forgotten, so that in thinking of the progress made in this field, one is liable to be struck by the disquieting thought that many of these forgotten developments may themselves have been possible turning-points in the line of progress which, if followed, would have brought us to an even better position to-day than we now occupy.

It is difficult, if not almost impossible, to turn back and follow up one of these discarded developments, and it is therefore of the greatest importance that our minds should be open to consider all possible developments, so that, so far as is humanly possible, progress shall really be along the best lines.

London, January 8 ; Leicester, February 24, 1937.
(Vol. XVI, No. 6, June, 1937)

We may take it, I believe, that when a machine tool development is offered on the market, it represents the considered confidence of the maker of the machine tool, who may be presumed to have a reasonably wide knowledge of the state of the art in his own field. Also, it should be added that in many cases such developments represent the collaboration of the actual users of such machines, not only in the way of consultation and discussions during the development of design, but also in the later experimental period with the first developed machine. These circumstances surrounding development by collaboration to which I have just referred, are usually such as to ensure a favourable reception to the developed machine, and a receptive condition of mind on the part of the personnel concerned in the use and maintenance of the new machine.

It does not follow, however, that this favourable atmosphere is present wherever the improved machine may be installed, and progress is only effective if a sufficient number of users afford this friendly atmosphere.

It is, I believe, a general experience that machines containing new developments are more favourably received, and more correctly used, in modern factories where machines embodying recent developments are already in use, and that, in a works containing older equipment, disagreeable experiences are much more likely to occur in connection with the installation of machines incorporating the latest developments.

If you are in agreement with these opinions, you will undoubtedly agree with my statement that the subject of my paper is very important, as a general discussion on developments, recent and now in progress, will enable us to judge properly of the importance and desirability of these developments, and, by so doing, enable us to influence their acceptance, and the consequent progress, in the best direction. In fact, as I have already stated, progress consists of what is understood and accepted by a reasonable proportion of users, and the discussion of such a subject may be expected to accelerate and ensure the progress which we all desire. It should be unnecessary to remind production engineers that constant changes in design are expensive, and that even a machine-tool maker appreciates a continued run of an established model. At the same time, developments are called for by competition and by developments in materials and processes, as well as by other demands. The consequence of this is that developments must be made in the way of detail improvement, rather than by drastic re-designs and the introduction of new models. In fact it is generally experienced among machine-tool makers that drastic new models only in exceptional cases pay for their development charges, and that the safest rate of development is governed by the rate at which users generally may be expecteod to accept new ideas. Under these

circumstances step-by-step improvement in the details of machine tools usually leads to a compromise, and even in the case of entirely new model machines containing the results of many detailed developments, there is still a great deal of compromise between the interests of the different improvements. Therefore I propose this evening, not to describe to you machine tools; but to direct your attention to many recent detailed developments, and to illustrate them with machines embodying these, giving you my views of their advantages from different viewpoints.

The object of a machine tool being to produce work of the required quality, and over a reasonable machine life, and at the same time to give the maximum output with the minimum of effort or strain on the part of the operator, naturally placed first in our discussion the machine elements concerned with accuracy and durability, and in this connection I propose to use the following headings: Machine frames, guides, spindles and bearings, drives and feed mechanisms.

The requirements in the machine frame are, that it shall connect as directly as possible the workpiece being operated upon and the cutting tools which operate upon it, and that it shall be as stiff as possible in this connection to produce the desired accuracy under normal cutting conditions; also that it shall not be liable to develop injurious vibrations due to the natural periodicity which occurs in many cutting operations, e.g., milling.

The first point, the closeness of connection of the work and the tool, depends upon the general scheme of the machine, rather than upon detailed design, and, though of great importance, is with many types of machines very difficult.

An example of the attention being given to this is shown in the recently developed method of finishing toothed gears by shaving them with a master gear or rack in the form of a cutting tool, in which case the final generated form of the gear tooth is produced by a rolling movement of the tooth itself, instead of depending upon a very indirect gear transmission such as exists in most gear-cutting machines. The most favourable type of machine to meet this point is the type in which only one moving surface exists between the work and the cutting tool, such as occurs in surface grinders and cylindrical grinders.

A particularly difficult type of machine in this connection is the ordinary knee and column type milling machine, with its number of joints and its open C form of frame, and this occurs in connection with the most intermittent type of cutting, namely, milling. In the type of milling machine with the fixed height table, generally used for series production, the frame is naturally more rigid, and therefore much more suitable for the intermittent action of a milling cutter.

Machine frame castings are nowadays generally of a cellular form rather than of the box form of some years ago, this being effected by dividing the cores into a larger number of pieces and leaving many ribs, or by dividing up the plates on their internal surface by a large number of crossing ribs, and so dividing what would be large flat plates having a low periodicity into a number of small plates having a much higher natural periodicity, and by this means making the frame resistant to vibration, rather than responsive to it. In the case of lathe beds, a " W " disposition of the ribs allows of greatly increased rigidity without sacrificing swarf disposal. For single spedial machines, it is now quite common to fabricate the bed from steel plates and sections, and so long as the thickness of plate is not much less than would be used for the corresponding casting, rigidity has proved satisfactory. The sliding surface of such beds must be well lubricated and fully protected.

The next most important quality of a machine tool is the suitability of the guides, and many changes have been made in these during recent years, particularly in connection with their protection from falling swarf, and the exclusion of this from the load-carrying surfaces. For long slides such as occur in large turret lathes, the form of cover consisting of a channel section of steel passing through a suitable tunnel entirely through the moving slide is the only convenient form, as folding and collapsing fabric covers have been found wanting, except for the lightest work.

Where the length of slide movement is moderate in relation to the length of the bed, a good form of cover has been developed which lies flat upon the slide surface and is in such intimate contact that dust and swarf cannot enter.

Recently there has been a revival of interest in guides of cylindrical type, and for a comparatively short movement these are fairly successful, but for longer movements they present considerable difficulties. One advantage of the round type of guide is that it can be cylindrically ground with considerable accuracy, and at moderate cost.

Flat slides are, however, nowadays quite often finished by grinding, and experience with these appears to be proving that the durability of the ground slide surface is greater than the previously used scraped surfaces, and that they are less liable to galling and local wear.

In referring to bearings in connection with machine tools, I refer, of course, to those bearings which have a direct influence upon the accuracy of the work, that is to say, the spindle bearings which constitute a link in the frame diagram of the machine. Working requirements presented by different materials and different cutting tools have a great influence on the selection of the most suitable

bearing, also the finish and surface quality required has a great influence. For a special purpose machine tool, or one which only requires a moderate range of spindle speeds, ball bearings or taper roller bearings have been found suitable for heavy work, but are rather liable to permit of chatter, by transmitting also the natural torsional vibration of the driving mechanism, if the load is naturally intermittent.

For fine finishes, either in boring or turning, the lubricated journal bearing is still the favourite, as with the moderate speed range above mentioned, such a bearing can be adjusted satisfactorily, and only needs very infrequent readjustments.

In such machines the spindles are often now made of nitralloy steel which, with the proper surface finish, meets all requirements. In certain grinding machines, such as the Churchill cylindrical grinder, a type of bearing has been introduced in which the bearing adjusts itself automatically to variation in oil film thickness by means of suitably loaded hydraulic cylinders bearing on one half of the bearing.

In general purpose machines, however, where the speed range is very wide, it is vey difficult, if not impossible, to use a lubricated journal bearing, as the requirements of oil film thickness for high speeds are very much greater than the same for quite low speeds, a result of which is that the joint formed in the frame diagram by the bearing will be too free at low speeds. The alternative is to use preloaded ball or tapered roller bearings, and even these are liable to give trouble in the case of very wide speed range.

Drives have in recent years divided themselves between the high-speed cutting, fine surface finish class, where a final drive is usually by an endless woven belt or by a number of endless Vee belts, and the moderate speed, heavy work machines in which the heavy gearing used some years ago is quite commonly displaced by a gear-box containing small high-speed gears, with a final heavy reduction transmitting to the work spindle. In some cases this last reduction takes the form of a worm and wheel. The advantage of this type is that the components of the high-speed gear-box are less responsive to intermittent action at the cutting tool, and tend to discourage rather than assist in the setting up of chatter. The gear-boxes nowadays have hardened and ground gears, and the shafts are commonly of splined type and are short and stiff.

Several examples have appeared of machines in which the spindle speeds are pre-selected on similar lines to that used in motor cars, but the economy of this is not generally commensurate with the cost.

It has often been asked why " synchromesh " gears are not used on machine tools, but the definite answer to this is that the machine

tool is not driven by a prime mover which can be accelerated or decellerated as such a gear would require.

In speaking of the final heavy reduction in the spindle drive, I would also point out that the same object can be achieved in a degree by the use of a substantial fly-wheel on the work spindle itself, and on a milling machine of moderate speed this has proved advantageous.

Where clutches are used as a means of connecting from the initial drive by a belt or motor, the use of multi-plate clutches is now very general, and I think it will be found that such clutches are very commonly of specialist manufacture, and, if selected to suit the drive, they are very satisfactory.

The use of slip-change gears on fixed centres is nowadays a very common means of obtaining changes of speeds and of feeds, and for machines specially set up for continuous running on a certain operation, they are undoubtedly in favour, but for general utility machines of the class I am particularly discussing they are only used for selecting the general range of speeds, and are followed by a change-gear arrangement giving a moderate number of changes. By their use in this case, one can obtain a range of fairly high speeds suitable for operating on light alloys or, by the use of another pair of gears, a different range suiting any other material.

I have mentioned several times those elements of the design which tend to resist the natural vibration which will be set up by the cutting operation, but I would also refer to attempts to minimise this tendency by arranging the cutting action in such a direction as to produce a more stable condition in the machine, by substituting tension for compression in the tool-carrying members. For example, some recent lathes run in the opposite direction from the conventional one, and in so doing place the tool-carrying members in tension, which is a more suitable condition than compression, but this must of course, be provided for in slide design.

Another development which should perhaps be classed under this heading is that of Climb Cut, or " Down Cut " milling which is advantageous for certain classes of work, but which involves certain very definite changes in the design of milling machines.

Motor driving, and general use of electric auxiliaries, is one of the most noticeable and successful of the general developments in machine tools which have occurred in recent years. Individual motor drive might almost be said to be general, with its advantage in relocation of machines to suit changes in work routing. The general adoption of the polyphase network supply in this country has contributed greatly to this by encouraging the use of the simple squirrel-cage motors in many cases, and, as these will stand instant reversal, in very many cases they have cut out the use of clutches, the motor itself being used as a means of stopping, starting,

and reversing, avoidance of friction clutches, with their occasional need for adjustment, being a distinct advantage.

Pole-changing motors giving usually up to four definite speeds, depending on the periodicity of the supply, are also coming into use, and in some cases these speed changes at the motor constitute the only speed changes available on the machines, though in some cases a gear-box is also used, dividing up the speed steps provided by the motor into finer steps to more exactly meet requirements. This quality of simple and safe reversibility of the squirrel-cage motor has also allowed its use for auxiliary movements such as a feed drive and quick power manipulation through idle movements, so that machines having complicated cycles of movement, such as intermittent feed and quick power traverse on a milling machine, are now possible without the use of dog clutches, which are difficult to operate under load and cause serious shocks in the transmission mechanism under modern conditions of working.

As the stopping of a high-speed motor occupies a little time, it is now fairly common to use a " plugging " method of switching by which the stopping of the motor is actually a reversal of the current, upon which the motor comes to rest very quickly, but immediately a reverse direction motion occurs the reverse direction current is automatically cut off. This ready reversibility of A.C. motors is also exact enough for use in tapping machines and others involving a fairly regular point of reversal. The use of individual motor drives also presents an opportunity of controlling tool condition by the use of a built-in ampmeter, and by this means foreseeing approaching failure.

The feed mechanism of machine tools has also been subjected to considerable development. I have referred above to the use of motors for feed drives, and the possibility of avoiding disagreeable clutch engagements by their use. This has also been achieved for certain machines by the use of hydraulic feed mechanisms, and for grinding machines, drilling machines, and boring machines, hydraulic feeds have certainly proved very suitable.

Hydraulic feeds are particularly advantageous where the cycle of movements involves a definite end position, as the hydraulically moved member can move against a dead stop and, by the use of a suitable relief valve, the pressure of the slide against the dead stop will be fairly equal at every repetition. An adjustable dwell on the deal stop is also quite easy to obtain, and all these avoid any shock or overloading of the feed mechanism. Another advantage of hydraulic feeds which is often made use of is the possibility of obtaining quite complicated cycles of movements of the various members of a machine, and the ease with which these are inter-

locked, so that no disturbance of the cycle can occur. Such cycles are available on the hydraulic feed milling machines which are now on the market.

Rotary drives by hydraulic motor such as would be required by the spindles of machine tools have not as yet made much headway, but they have actually been supplied for such purposes.

The points dealt with up to now may be classified as concerning the general stability and capacity of the machine, but, however well these qualities may be embodied, they still leave for consideration the means provided to enable the operator to produce the quality and quantity of work required, and for reducing the stress and effort required in doing this. I propose to discuss these qualities in the following order: Accuracy, convenience, lubrication, and maintenance.

With the ever increasing demand for better, finer quality interchangeable manufacture, the demands for accuracy will apparently always be somewhere ahead of the possibility, and this has prevented the adoption of a principle often spoken of only a few years ago, in which the precision required was to be built into the jig and tool equipment, and to require only a very simple, rough kind of machine for rotating and feeding the cutter. But we find that modern requirements make necessary not only all possible accuracy in the jigs and equipment used, but also in the machine tools upon which they are used. It must be realised, however, that very fine tolerances in alignment, etc., on large machine tools are much more costly than similar tolerances on a small self-contained jig, and that it would be uneconomical for the purchaser to specify such tolerances. It is, however, very desirable that the purchaser of a machine tool should specify tolerances of alignment and accuracy of the machines in his inquiry, and not neglect this point as is usually the case, and which omission often leads to disagreeable discussion after installation. In so specifying alignments and tolerances, it should be borne in mind that these can only be measured on the machine at rest and unloaded, and that in actual service the accuracy of the work produced is influenced by the load deflection of the machine itself, and also by the form and stiffness of the workpiece itself, as well as the rate and uniformity of metal removal.

Constructional developments of the machine tool itself, in addition to general initial alignments and stability of slides and spindle design, include the methods of making the settings which control dimensions of the work. In this respect the most notable development is the change from dead stop working to the use of sensitive indicators which give the actual position very accurately, and are not subject to varying dead stop pressures, which is a common cause of error under the old system. These dial indicators, used

together with accurate and measuring members or gauges, enable relative positions to be obtained with very great accuracy. A further step in this direction has been achieved in connection with a well-known jig boring machine in which even the best screws combined with compensating mechanism have been discarded in favour of a very accurately engraved scale, read in connection with a microscope.

The above considerations, however, apply to positioning parts of the machine, and are still subject to variation in the work or the condition of the cutting tool, and have given rise to a further step in the cases of certain cylindrical grinding machines where the operation of the machine is controlled by a sensitive measuring instrument applied to the work itself ; in one example the photocell is used in connection with a sensitive lever measuring instrument, and it is claimed to produce cylindrical work to a diameter tolerance of about .0001 in.

In most cases, however, the cutting action is too heavy for the use of this method, and some dependence is still placed upon the attention of the operator ; for this reason adjustments are made by more sensitive methods, and delicate dial indicators are used to enable reliable repetition of settings.

While speaking of the operator, one must mention the continued development in convenience of grouping of the controls, which has now reached a considerable degree of perfection in connection with general purpose machine tools, though there is perhaps still room for further developments in connection with those movements demanding a considerable effort, either by way of operating these by power, or by so arranging them that the effort required does not result in an excessive fatigue or strain of the operator.

As already mentioned, the growing adoption of tungsten carbide and similar cutting materials has had a considerable influence on recent developments, and, by necessitating a general review of methods, has given an opportunity for the adoption of new methods of attack, such as climb cutting in milling practice, and the running of lathes in the opposite direction as already referred to, which latter, incidentally, greatly reduces the swarf disposal problem. The slight horsepower cost of using chip breakers on lathes running in the ordinary direction does not seem to be acceptable, but in my opinion something of this kind will eventually be accepted.

Production lathes of the centre lathe type are increasing in number, generally using a multiple tooling method by which several diameters are turned at the same time, and shoulders cut in by a transverse slide. In certain of these short length multi-tooling lathes, cylindrical slides are used, as mentioned earlier in the paper.

The many developments above discussed have been demanded by increased speeds and increased rates of production, with in-

creased loading on the parts of the machines, and naturally demanded changes in methods of lubrication and also an increase of responsibility upon the maintenance personnel. Though a machine may have a good system of lubrication distribution, it still requires that suitable lubricants should be supplied to it at the necessary intervals. In fact machine-tool makers have caused themselves a lot of trouble in recent years by trying to make the lubrication system of machine tools too simple, often using a lot of long oil pipes which are liable to either become stopped with gummy oil, or to receive less oil from the supply than their shorter neighbours, so that the tendency appears to be growing to use a grouped nipple system in which each main element of the machine has a group of oil nipples for the use of an oil gun, and these are grouped so that they can be readily served. The use of an oil gun on each nipple in sequence ensures that each lubricating point receives its quota. This, of course, leaves the lubrication of gear boxes, etc., to be carried out by splash methods as before, though a more liberal use of oil level indicators is desirable.

A further interest of the user is that of accessibility for adjustment and examination, which in general purpose machines is nowadays carefully considered, but this convenience and accessibility does not usually lend itself to the smooth and self-contained appearance which some users seem to favour, though there is a tendency to the wider use of safety devices such as shear pins, and slipping frictions which greatly reduce the probability of accessibility for replacement being necessary.

But with all these developments in design of machine tools, there is a need for corresponding development on the part of the user in relation to maintenance in service, notwithstanding all the facilities provided for this by different makers, and this is a necessary feature of competitive development. The user should therefore have the necessary breadth of view and so collaborate in guiding progress along right lines. Standardization we may hope to see in respect to details concerned in the interchangeable use of cutting tools and equipment, and in fact, your collaboration in this field would constitute a valuable service. But standardization in the constructional details of machine tools would be very undesirable in view of its hindrance to progress in design.

In conclusion, I wish to tender my thanks to the many firms who have assisted me with the loan of slides and data.

LIST OF LANTERN SLIDES

No.	Machine	Maker	Point Illustrated
1 and 2...	Tooth shaving machine	Fellows	Direct generation of gear teeth
3	Manufacturing miller	Archdale	Vibration resisting closed frame, worm-geared spindle, flywheel

No.	Machine	Maker	Point Illustrated
4	Horizontal boring and milling machine	Kearns	Modern bed design
5	Turret lathe	Ward	"W" ribbing of bed
6 and 7 ...	Turret lathe	Ward	Fully covered bed and slides
8			
9	Turret lathe	Herbert	Fully covered bed and slides
10 ...	Horizontal boring and milling machine	Kearns	Fully covered bed and slides
12 ...	Vertical miller	Archdale	Belt drive, high speed spindle
14 ...	Gear lapping machine	Werner	Lapping method
15 ...	Gear grinder	Maag	Generating gear grinder
13 ...	Lathe headstock	Lang	Heavy final gear reduction
16 and 17	Turret lathe	Herbert	Pre-optive head
18, 19, and 20	Vertical miller	Kendal & Gent	Use of slip gears on general purpose machine
21 ...	High speed lathe	Magdeburg	Round guides and inverted cutting tool
22, 23, 24, and 25	Plain horizontal miller	Jerwag	Climb cutting miller
26 ...	Draw cut shaper	Butler	Unconventional direction of tool motion
27 ...	Capstan lathe	Herbert	Built-in pole-changing motor
28 ...	Sensitive drilling machine	Archdale	Built-in pole-changing motors
29, 30, and 31	Vertical auto	Ryder	Electrical gear fully included in design
32 ...	Slot drilling machine	Craven	Hydraulic with dead stop stroke
33 ...	Six-spindle cylinder borer	Archdale	Hydraulic cycle
34 ...	Reciprocating feed drilling machine	Archdale	Hydraulic cycle
35 and 36	Clutch plate miller	Archdale	Duplex machine with hydraulic cycle
37 ...	Hydromatic miller	Cincinnatti	Hydraulic cycle
38 and 39	Die sinking miller	Deckel	Dial and gauge setting
40, 41, and 42	Jig boring machine	Soc. Genevoise	Replacements of screw by scale and microscope
43 ...	Centre lathe	Lang	Grouping of controls
44 and 45	Radial drill machine	Archdale	Grouping of controls and speed changing
46 and 47	Planer	Butler	Grouping of controls
48 ...	Horizontal Boring and milling machine	Kearns	Grouping of controls
49 ...	Lang Heinemann lathe	Lang	Multi cutting.
50 ...			
51 and 52	Production centre lathe	B.S.A.	Multi cutting.
54 and 55	Turret lathe	Ward	Oiling diagrams
56 ...	Gridley automatic	B.S.A.	Centralised oiling

Discussion, London Section.

MR. B. C. JENKINS: Before opening the discussion, I just want to say that I had an advance copy of Mr. Wright's paper and I found it so provocative that I felt I could sit down and write a paper six or seven times as long as his. So many points were open to discussion that I did not find it difficult to get them out, and I propose to all intents and purposes, to read what I have to say.

Much development and experimental work is wasted owing to failure to analyse logically the reason for results not coming up to the expectation of the person in whose mind the idea was conceived. Frequently, a closer contract between the technician and the practical man would enable the idea to be brought to a successful and fruitful conclusion. A totally unsuccessful development is often turned into complete success when allied to further and independent developments.

Co-operation between designer and user is a vital necessity but it must be true co-operation in the widest sense of the word, with a realisation that both have a common objective which is to obtain the best possible product at the lowest possible overall cost. The machine is only a means to that end. Destructive criticism is useless, constructive criticism is priceless. It is a human failing to object to and tend to fight criticism of any nature, however well meant. If the machine tool user is to co-operate with the designer, his criticism must be frank, constructive, and free from bias and must be accepted by the designer as *being so*.

Favourable reception of new designs, is largely a matter of selling the personnel who have the physical handling of the equipment. Previous experiences with equipment from the same source of supply have a great bearing on the reception of any subsequent machine offered. Exaggerated claims as to the virtues of a given machine will often jeopardise its chances of success.

Production engineers certainly realise that changes in design cost money. It is agreed that development in the machine tool field as in most others, must be by detail improvements. Designers frequently completely spoil the effect of detail changes in machine tools, by not carrying the improvement far enough and so getting what may be called a state of unbalance in the design. This often completely nullifies any benefit which might accrue from the alterations carried out.

The statement that it is only in exceptional cases that new models pay for their development charges, would appear to require some further explanation. If the improvement in the new model over the

old is insufficient to attract the machine tool user at a price carrying a fair proportion of the development charges, surely that is an error for which the designer and manufacturer must expect to pay. In other words, it is a commercial risk. On the other hand, I have yet to learn that the machine tool manufacturer is either a philanthropist or that he suffers from excessive shyness when asking a price for new designs. May I suggest that in many cases, a dose of his own medicine would be beneficial. In other words, use more up to date plant and methods and check up on his cost accountancy system. Many hidden leakages would, I imagine, be brought to light if this was done.

I am in agreement that the lubricated journal bearing is better than ball or roller bearings when fine finish and accuracy is desired, provided, always, that cutting conditions are suitable. We have on numerous occasions replaced ball and roller bearings with journal bearings owing to the impossibility of getting desired results. This has been done with the knowledge, consent, and agreement of the manufacturer. On the other hand, one must agree that the present standard of ball and roller mounted spindles is suitable and advisable for 95% of modern production machinery as used in motor car and allied production shops.

Reference was made to the use of lathes running in such manner and direction as to place the tool carrying members in tension instead of as conventionally under compression. This brings me to the thought which arose when the author referred to the design of machine frames and the necessity for rigidity in tool carrying members. My thought was, is it rigidity we require, or do we want a cushioning effect of a controlled nature? My own opinion is that the latter is the ideal, but I appreciate the difficulty of obtaining this ideal in many classes of machine tool. This is a fruitful field of experimentation for the machine tool designer. Strange how we return to the ideas of the old craftsman exemplified in this case by the old spring form tool or the swan necked inverted parting off tool used in conjunction with crossed belts.

It gives me great pleasure to see the tendency toward this form of drive as the firm with which I am connected were pioneers in this field. The greater flexibility of the plant and the comparative ease with which plant rearrangements can be *carried out, amply repays first cost.*

I am rather surprised to know that any volume of considered opinion ever favoured the idea that a rough type of machine in which alignment was a secondary factor could be used in conjunction with accurate jigs to produce a satisfacory product. It is true that this can be done successfully up to a point but malalignment always has its reaction either on the jigs, tools, or product. Even in the simple type of machine which may be termed a tool carrying and

rotating member, alignment, of a close character, is necessary and worth paying for if accurate work is to be produced.

I am not in agreement with the author when he suggests that grouped nipples, fed individually with a gun are a satisfactory solution to what one may describe as secondary lubrication points. All lubrication should be automatic and I would suggest that something in the nature of the Tecalamit system timed to feed these points at regular intervals when the machine is in motion, would be a more satisfactory solution.

I would suggest that the question of accessibility for maintenance purposes is one of the most outstanding requirements in machine tools and far exceeds in importance the looks of the machines. Generally, a machine can be quite a clean workmanlike job and still remain accessible. In this connection I suggest that accurate unit construction arranged for easy and quick assembly will be found to be the solution to many of our troubles on standard types of machinery. The use of shear pins as safety devices is rarely satisfactory and I would suggest that the alternative of spring loaded adjustable slipping clutches combined, in the case of motorised machines, with an electrical cut-out are much more reliable.

I have purposely left these two items until last and I notice the author touched very lightly upon standardisation. There are many facets to this question of standardisation and I am very definitely against the author when he suggests that standardisation is any bar to progress in the machine tool or any other field. Production engineers do not wish to dictate to the machine tool designer or manufacturer what he shall or shall not do, but they are prepared to work in conjunction with them in arriving at satisfactory standards of accuracy. The author suggests that tolerances or standards of alignment should be laid down by the production engineer or the machine tool buyer when placing orders. I ask in all humility, does the author wish to suggest that any production engineer is in a position to lay down such standards and such tolerances with a degree of accuracy greater than that within the knowledge of the machine tool designer. He knows that in many cases malalignment must be built into the machine if accurate work is to be produced.

I must again suggest that the work of our friend Dr. Schlesinger should be taken as a starting point and that a centralised research department subsidised by the machine tool and the engineering trades of this country is an outstanding necessity. Standards of alignment and tolerances laid down under such auspices would then become available and could be quoted with confidence when ordering machine tools. I, personally, shall never be satisfied until this dream of mine becomes an established fact.

I want to make reference to one of two of the slides. One of them is the Fellows shaving machine, and I would like to ask Mr. Wright if

he considers that the Fellows shaving machine is actually as sound as the Michigan machine. I think the Michigan machine, where you get a rack which you can measure and check and set the position of blades accurately, is the one and only sound method which has so far been offered to us to eliminate inaccuracies. I am of the opinion that the Michigan machine is by far better than the Fellows machine. As regards lapping, I would like to say that the lapping machine can never make a bad gear good, but it can make a good gear bad. It is generally used for improving the surface and it must be very accurately and very carefully handled. Another point about which I very definitely disagree with Mr. Wright, is with regard to his statement that the preselective mechanisms are not of very great use. I think it will be agreed that where the operations on various diameters are of short duration, the pre-selective heads are definitely a big advantage. The easier one makes the change of speed to be, the more likely the operator is to use them. That is our experience in the use of such machine tools. In conclusion, I would like to thank Mr. Wright for his paper and for the interesting way in which he has got it up, and I would like also, to ask him at some later date to give another paper with something more of Continental and American machines brought forward for our attention.

MR. WRIGHT: The first point which Mr. Jenkins raised was the trust and collaboration between the technical man who is going to make out a scheme and the man who has been doing this job by some other way for some years previously, and anyone else they can bring in for the discussion who has got plenty of experience of that particular job from the machine tool makers' point of view. I think that one of the difficulties in the case of machine tools which are offered against a definite production inquiry is to get in contact with the actual experience of the user who has been doing this job in some other way for some time. This contact and collaboration between both parties, the maker and the user, is very necessary. That does not mean the maker's salesman and the user. Mr. Jenkins spoke rather feelingly about the machine tool makers and their attitude towards critics. Machine tool makers, like anyone else, when an outside customer approaches them and discusses a job to be done, immediately thinks, "Oh! This is a customer for one of our so-and-so machines," and if the customer makes a lot of suggestions, the machine tool maker says, "Oh well! Those do not matter. This is the machine you really want." I think that if the user, the customer, could get past the salesman who is trying to sell him this article, to the technical people, they may be persuaded that there was a little sense in his criticism, but the machine tool maker's general interest would be to sell one available model of machine.

The English machine tool trade is in a peculiar stage of its develop-

ment now. A few years ago, the machine tool maker never made anything until the customer told him exactly how he wanted it made. Nowadays we are trying to get to a stage where the machine tool maker puts individuality into the machine tools and he does not feel very free to accept immediately any criticism or suggestion without very full discussion into the reasons.

Mr. Jenkins also objected to my saying that an entirely new model often does not justify its development costs. I did not mean by that simply a completely redesigned machine following on an old one. But a new machine for tackling a job in a new way, even though the job may be one which occurs in many new industries, the odds are several to one that it will not be accepted in sufficient numbers for many years to actually redeem the costs of building the new machines. I have had some experience of it, in particular with a machine that I designed now fifteen years ago. About four were sold. They gave every satisfaction to the people who used them in the trade they were suitable for. But within the last couple of years far more of these machines have been sold than were sold at that time. They are not any better. They are exactly the same and are made on exactly the same design as those made years ago. People have seen them and got used to seeing them and they say, "We had better have one," and it has taken fifteen years to do it.

Mr. Jenkins recommends the machine tool trade to use its own medicine. Well, I think it has been using its own medicine too long and not been using enough of somebody else's medicine. Mr. Jenkins, I think, means that machine tool makers should instal in their works modern machines which will not be necessarily competing machines, and that that should be inspiration to them to develop a bit more rapidly on their own machines. Some machine tool makers are doing that, but there are still some machine tool makers who have been so hit during the depression that they have not yet reached the stage when they think of buying anything which they can make themselves.

Mr. Jenkins spoke in confirmation of my remarks on the supporting of cutting tools by tension. I am particular glad to hear Mr. Jenkins mention that, because I was raised in the days when people used carbon steel tools and put a parting off tool at the back and the lathe cut upwards and that kind of thing, and it was perfectly common practice to do so. But when you are using high speed steel which will do anything if you will only put plenty of power in it, there is no need for such technique in cutting. I should like to show him one or two special machines I have designed where circumstances have made it possible to use that principle, and you cannot get a chatter on these machines.

I agree the variety of lubrication methods is rather discouraging. I know that some machine tool makers do get themselves into a

lot of trouble. On the very big press that Mr. Jenkins has in mind and like the four spindle automatic I showed, you cannot go too far. But when you have done as much as you can with the machine it is still up to the people to keep it supplied with oil or trouble may arise. On very much less expensive machines you may easily spend a lot of money on lubrication and still get into trouble at the end of it. I was speaking as a machine tool maker in my paper, and Mr. Jenkins was no doubt speaking as the user who is worried with the breakdowns that arise.

With regard to unit construction, in connection with accessibility, for taking off a lathe head or something of that kind and sticking another in place of it, or sending for one from the makers, I did mention that in a machine tool of any size the difficulty of getting alignment accuracy is present, and I quite agree with Mr Jenkins that you want alignment accuracy. There is a certain amount of adjustment necessary in assembling these large pieces to get near the accuracy required, and I have never heard of any practical suggestion for getting interchangeability of lathe heads and slides and things of that kind, though with a feedbox we may do that. Mr. Jenkins criticized my reference to shear pins. I am not very familiar with shear pins and very seldom use them and in my opinion the tapper type of safety slip is the best because it resets itself.

MR. JENKINS: That is the one I referred to.

MR. WRIGHT: That is the best kind you can obtain I think, but is of course more costly. Mr. Jenkins spoke about standardization. I know, of course, that our Institution has interested itself in standardization and I know that my confreres in the machine tool trade refuse to standardize the Schlesinger system of tolerances for alignment. It seems to me that if the purchasers of machine tools, who are production engineers generally, will specify Schlesinger tolerances in their machines, they will get them. It will be something definite and the machine tool maker will conform to them and they will realise, after they have done it for a year or two, that those standards are necessary. That is my suggestion to the production engineers, that if they want to encourage the establishment of standards of alignment they should say Schlesinger alignment, or allow twice the tolerances if the work is rather rough; but do not start talking about tenths of thousandths on machines 20 ft. long. It cannot be done—well, it would not be so after the machine had done a couple of miles on the road, either a railroad or an ordinary good road.

Mr. Jenkins referred also to my note on the speed pre-selective machine. I think that the pre-selecting gear on small work where speeds are constantly being changed is very desirable, and I believe the small lathe with a pre-optive head has been quite successful.

I have tried pre-selection on certain milling machines and have tested the changes of speed in ordinary work, and (we are not on mass production lines at all) the changes of speed are so infrequent that it does not amount to any particular advantage. It costs a lot of money and introduces a fair amount of complication, and is not a thing to be generally recommended. There are, of course, cases where it can be used. I thank Mr. Jenkins for his comments and I am quite pleased that he has not been far more critical than he has.

MR. BLACKSHAW: I cannot hope to debate on the subject of to-night's lecture to the same extent as the previous speaker, Mr. Jenkins, for I have not had his advantage of having read the paper beforehand. One or two points have, however, arisen in my mind during the lecture upon which I would comment. Firstly, that of hydraulic feeds to which a good deal of prominence has been given of late. From the information I have been able to gather it would appear that generally speaking they as yet leave a good deal to be desired, and in particular with regard to consistent working, particularly where wide temperature variations obtain. I would like Mr. Wright's views as to whether he considers hydraulic feeds suitable where it is essential to have constant linear movement.

Mr. Jenkins raised the matter of machine tool lubrication. My experience leads me to believe that machines are designed and made and then someone comes along and just sticks on a few paltry oilers, more for appearance apparently for they are seldom any good in practice. I feel this matter calls for a good deal of attention, and I am definitely in favour of positive pump lubricating system fitted incidentally with a really satisfactory filter. Reverting to the pump drive, this I suggest should definitely be gear driven. I was pleased to hear the reference to the machine tool limits. I cannot understand why advantage has not been taken of the work of Dr. Schlesinger, and his system of standards. Perhaps Mr. Wright can tell us why the machine tool builders in this country have not adopted same.

Independent motor drives were referred to, and I know there are many people who will hear of nothing else. Whilst I agree that viewed from the idealistic angle there is nothing to surpass it, I do suggest that it is not necessarily the best commercial proposition, and particularly if one's power supply is direct current. For the large motor car manufacturing concerns where location of machines is often changed, I think it scores every time. For every motor car works, however, there are hundreds of other engineering firms which would be covered by saying their work is of a general engineering nature, and where the necessity does not arise to constantly change machine location. In such cases the grouping of say six machines or so to a single line shaft has much to commend

it, and will generally be found to be a better commercial proposition than individual drives, and particularly so if the machines are of an order such as absorb around say 1-5 h.p.

Mr. Jenkins stressed the point of co-operation between machine tool designers and users. I certainly endorse his remarks in this direction. Maybe I have been particularly unfortunate, for my experience has been such that I have come to the conclusion that the word " co-operation " just does not exist in the vocabulary of the machine tool builders, with the possible exception of when they are after your order—certainly not when they have got the order. However, I trust that we can look forward to the time when this very much desired co-operation will be a reality, and I can think of no better nursery in which it may develop and grow than within the walls of our Institution.

MR. WRIGHT: Mr. Blackshaw mentioned hydraulic feeds. For certain classes of work the hydraulic feed is simpler, less troublesome, requires less maintenance, attendance and replacement, than any possible mechanical feed. If the hydraulic feed machine is introduced into the shop wheih previously had no hydraulic machines something should be learnt about it—you should not allow some ambitious millwright to say he knows all about it and get things mixed up and so on. There is an individual technique in connection with the maintenance of hydraulic machinery. One interesting little point is that the amount of oil specified and the kind recommended by the supplier of the machine should be used in the hydraulic circuit. The hydraulic machine that I showed you, the complicated one operating on pressure plates, has been working now for over three years night and day, and there have only been two replacements on that machine and they were parts connected with the air cylinder for clamping the plate. The air cylinder came with such a bang on the clamp details that they were worn off in time and had to be replaced. The rest of the machine ran night and day. Someone did drop a casting on to a pipe and broke a joint, but that was quite soon replaced. In connection with any of these rather drastic developments it is of the greatest importance that the user of the machine and the actual persons concerned with running the machine should give it a friendly reception and a good try-out before condemning it. As for providing by hydraulic means a definite linear motion, whenever hydraulic machines come up somebody has to say that you cannot drive the saddle of a screw lathe hydraulically. I believe it has been done, but the movement is limited by a screw—the screw sets the pace. In fact changes in oil temperature and viscosity have some effect on all hydraulic feed machines. As a rule a machine will run rather sluggishly in the morning when the oil is cool, but after half an hour's or an hour's running it settles down to its pace for the rest of the day. Many

attempts have been made and I can mention one firm which spent hundreds of pounds to make offsetting schemes by which the viscosity is regulated so as to get a constant rate, but if you change the make of oil or something of that kind it has all gone west.

I agree with Mr. Blackshaw that a machine from a new works essentially means different ideas about oil distribution, and it is up to the customer, if he wants to get full value from the machine, to use it in a friendly fashion.

I sympathise with Mr. Blackshaw in connection with his criticism of gear pumps. The amount of coolant present in the machine means there is no place for swarf to settle before reaching the pump, and this wears them out. There are some good ones but they do not last for ever. My selection in every case is the three phase motor electric pump.

I agr e also with Mr. Blackshaw in connection with motor-driving. The group driving for groups of small machines is more economical and in many respects quite convenient. I only say that the provision of motor-driving facilities is common on quite a lot of machines. It is not uncommon now that the standard demand for machines is for the motor driven machine, and if you want a belt drive it involves extra detail.

Mr. Blackshaw also refers to the small shop as being the backbone of the industry. Well, for the last twelve years it has been a very weak backbone. The only demand for machine tools for many years now has been in the motor car trade, up to a couple of years ago. Now we are, of course, improving. There are other establishments and industries which are beginning to take machine tools, but the motor car trade was the market for machine tools for many years, and it has had a very great influence on the design of machine tools, and it means that the tools used in motor car work have been subject to much more development than those not much used in motor car work. Now, fortunately for us, all industry generally is in a much better condition and the small shops, the shops that five or six years ago could not think about machine tools, are now actually buying them and have been for the last year or so.

Speaking of quality and finish, that I think is a question of the reputation and reliability of the firm you buy the machine from, and in the second degree probably a question of the price you pay for the machine. You can have all kinds of qualities and all kinds of prices, but if the machines are bought from a reliable firm, as a rule they will immediately make anything right that you say is wrong, though to them it may not be very wrong. Any respectable firm tests the machines before delivery and that leaves only the definite criticisms of the type of the machine or the arrangement of the machine.

MR. AIERS: I am sure that Mr. Wright will welcome the various

suggestions that machine tool users are making to-night. One of the points which has been discussed is how the machine tool user is to get in touch with the machine tool manufacturer. As a rule the salesman when he comes round, guarantees you certain figures and the type of finish you desire, but often actual production is not to standard. I consider that the better way is to make the various constructive criticisms at these meetings and the machine tool manufacturers should see that their men are here to join in the discussion and thereby help each other through these meetings. One of the points is the extra cost for standard tooling and attachments. You know that with the old motor car it was necessary to buy tyres and spare wheels, etc., but you never think of doing that now. With machine tools we are still in that stage. I think the makers should now begin to supply a reasonable set of standard tools and attachments with the machine. Mr. Blackshaw mentioned delivery, but if we had discussions and put forward suggestions how long would it be before we got them put into practice? Even now we talk of machines that we place orders for to be delivered twelve months hence. If we started talking about alterations would they materialise by 1938?

I have spoken to one or two machine tool manufacturers regarding swarf removal. Although foreign machine tools have already dealt with this question and supply quite satisfactory swarf conveyors, it was impossible to obtain any similar type of help from our own machine tool suppliers. With regard to separate motor drives, while there are many points for and against, one of the main difficulties is, that the machine tool maker of necessity fits some standard electrical equipment; the guarantee and maintenance, therefore, rests with the electrical supplier. When trouble occurs, which I have found to be fairly often, instead of obtaining quick service it needs to be reported to the manufacturer, who reports to his electrical suppliers, and they report to their local service depot, with the result that there is considerable delay instead of direct dealing. I think we should also stress the point already discussed regarding oiling and maintenance of machine tools. As we are aware, in most works time is allowed for operators to clean and oil their machines, but even when further inducements are given, a large percentage of the present-day operators will still neglect this important point. I do consider, therefore, that it is up to the manufacturer to fit an automatic oiling system, which would help to maintain the machines in good running condition.

MR. WRIGHT: Mr. Aiers first mentioned the question of contact between the technical side and the users, and the technical side and the purchasers. The best way to do that is to prepare a draft of the job you want doing, proper drawings of it, the material, its brinnel hardness, and any comments about any kind of cutting difficulties

that you may have had in certain cases, and so on—give the state of that particular job and send it to the machine tool makers whom you think of allowing to quote. In that case the inquiry will go to the technical people of the machine tool makers and will receive proper consideration. If you buy a machine as you would buy an orange, walking along the street, because somebody offers it to you, without discussing the work and what generally you are going to attempt on the machine, you may get a bad orange. That, I think, is the best way to ensure this contact.

Mr. Aiers spoke very feelingly about tooling equipment. With most machines, if you say that you want a standard set of equipment most makers are ready to propose a standard kind of outfit which will do general average work, and they will be very glad to include it in their quotation. The conditions are very different for a motor car. The necessary complete tooling equipment may not be known, and spare parts are added until the machine has been used for a few years, and you will then see what equipment has accumulated and know what you should have bought at the beginning !

Mr. Aiers was rather ironical, I think, about the possibility of any suggestions put by the production engineer to the machine tool maker reaching any conclusion before 1938. I do not think it would take so long. These things do, of course, move slowly. You probably know cases where the authorities in your shop have decided on a certain change in the product, and they come into the shop after three days and see some of the old stuff being assembled at the end of the line, they come dashing up and say that three days ago they ordered that this should be changed and here you are still assembling the old things. There is a kind of idea prevalent in many circles that if a change is decided upon the parts in progress are immediately replaced by new ones. It takes time to do this. If your suggestions and discussions are made use of at any time in the future, then you are helping to make progress.

The question of swarf disposal was mentioned. I said in connection with one or two slides that swarf disposal does receive some slight consideration, but this would mean in many machines such a change in the arrangement of the machine that nobody would buy it. Everybody would be frightened of it—it would be too new. For instance any turner is sure that a turning tool must be set in a horizontal position at the centre of the turning wheel, and it is traditions like that which affect the arrangement of the machine and prevent development very largely in connection with a good swarf disposal scheme. For instance you could have the lathe bed at the top and the swarf at the bottom, but nobody would buy the machine in that position !

Mr. Aiers spoke very feelingly about the trouble of electric maintenance. I mentioned more than once in the paper that with these

new developments, such as hydraulic feeds, and installation of electric driving, and the use of the electric motors for auxiliary purposes, the organisation of maintenance in the works has got to be prepared to deal with this. One of the costs incurred with these new developments is the employment of suitably instructed maintenance men to deal with the electrical matter and with the hydraulic matters, and also with lubrication. Lubrication seems to have come up in everybody's contribution and I will admit that it is a very important thing, but lubrication like charity, I suggest, begins at home.

MR. JENKINS: I hope I may be excused for rising again, but I just want to clarify one point in which I appear to be a nigger in a woodpile. This question of co-operation that I mentioned, I do not mean the co-operation between the buyer and the salesman. Generally speaking, the average man buying a machine tool listens to what the salesman has to say and takes that for what it is worth. He wants to see the machine and the inside of the machine and know something about it. The type of co-operation I had in mind is that in which the production engineer or the tool user passes on to the machine tool manufacturer his findings and any alterations which he may have been forced to make, any weaknesses he finds in the machine, with some suggestions for future models. Mr. Wright knows exactly what I mean because it is one of the things in which we co-operate with the firm he represents. We find that our offer to give co-operation has been freely accepted by their firm to such an extent that they use us very largely as an experimental department. They frequently supply us free of charge with improvements to machines which we try out for them. They ask us to try them out and we tell them if we have trouble in the tests, and if so, we make suggestions with regard to what should be done in order to correct that trouble. That is the one thing that is required between all tool users and manufacturers. For instance, we often find that new machine tools come in and some trouble arises. We could get it right in ten minutes and we are kept waiting by the machine tool makers for ages before they come to see what is wrong and put it right again. Frequently we have done something wrong ourselves and the makers are quite right, but we learn something out of it. That is the kind of co-operation we want between the user and the manufacturer. That is the type of co-operation I am asking for when I suggest that we should set up a research laboratory to take up all machine tool propositions and see exactly what is necessary in the development of machine tools, and I say this advisedly. It is a thing in which every machine tool manufacturer and every engineering concern is interested, although they may be separate entities. That is the one thing that we want and must have if we are to maintain our position in world trade.

MR. WRIGHT: I thank Mr. Jenkins for the complimentary remarks he made about my firm, and I believe there are many other firms which are quite ready to check the difficulties which arise with the machines and clear up any misconceptions on the part of the user, or to meet them with the difficulties that arise in use. But if the production engineer buys a machine from a catalogue, as I say, like buying an orange, then if the maker who sold the machine does not know what he wishes to do with it, he may be let in for quite a lot of criticisms and suggestions of serious alterations to the machine to fit it to the peculiar work that the customer has in mind. The maker of the machine ought to know in each case as accurately as possible the class of work that the machine is itended to be used for, and the first step in inquiring for a machine tool is to give the fullest possible information about it.

MR. WAYNE: Mr. Wright has made reference to the hydraulic machine. My experience of the hydraulic machine in the last ten years has been very very good and the work obtained has been very accurate. Also Mr. Wright made reference to the hydraulic chuck on the screen on the machine for milling clutch plates. He then rectified his statement by saying that it was a pneumatic chuck. I would like him to explain if it is at all possible why the hydraulic chuck is not applicable.

MR. WRIGHT: Referring to my slip in stating a hydraulic chuck and then correcting to a pneumatic chuck. When you close a chuck on to a piece of work you want to get at the finish a pressure on the biting parts of the jaws of the chuck, which can really only be done by a blow, and with the pneumatic cylinder, when you admit the compressed air the piston gets into rapid motion before the jaws strike the work, and the result is a kind of blow on the jaw so that the serrations of the chuck really bite the work-piece, the bite representing far more than the air pressure on the piston. You cannot get this slam with a hydraulic movement and that is in fact one of the beauties of the hydraulic movement, you cannot get a real slam, and if you want to do any really heavy chucking you would have to have a hydraulic pressure 10 times as big as the nominal air pressure in the pneumatic form. Electric chucks, for instance, have been made in which a motor operating a screw pulls a bar through the spindle and operates the chuck. The motor is in rapid motion as the machine touches the work and the rapid movement of the motor produces a kind of hammer blow on the biting surfaces. That is my experience.

MR. SCAIFE: I have enjoyed the various points Mr. Wright has gone through, but I think like—what is her name?—the lady who came from Ethiopia to see the temple—that half has not been told unto us. I think some of the most important developments that have occurred during the last few years have not been mentioned.

I would have liked Mr. Wright to have said something about surface broaching, which has been developed very largely during the last year or two in America, internal centreless grinding, and fine boring, which are all important developments. We ourselves have done a little in the way of new developments in machine tools, but of course as Mr. Jenkins said, it is a big subject and it would have taken rather a long time to go over the whole range.

There was one point, however, that Mr. Wright mentioned with which I was in entire agreement, and that is, I believe that it is the best thing in this Institution, I have always maintained it, to get a system of alignments adopted, and I think this Institution should take the matter in hand. We all know that alignments are one of the most important functions of machine tools, and I have been stressing that from the outset, that if the members of this Institution who have to buy machine tools were to agree among themselves that they were going to have a system of alignments, the machine tool makers or any other body would not be able to resist. The machine tool trade would have come into line, whether they wanted to or not.

The firm I am connected with is a member of the Machine Tool Trades Association, and I am rather a rebel in that direction. I have been pressing for a system of alignment standards for some time now and I can say without fear of contradiction that it is just as easy to make a machine tool to Dr. Schlesigner's standards as to make them any other way ; it is really a matter of going about the thing in the proper fashion and having the right tools. The job can then be done easier and at less cost. That has been my experience. Our system of alignments is based on but is generally closer than Dr. Schlesinger's limits and I can say that since we adopted it we have had less trouble ourselves with assembling and we have had less trouble with the work the machines have done afterwards.

In regard to the matter of co-operation—our system is to keep in touch with customers through our service engineers who report any suggestion made by them. These reports are examined by our technical staff and suitable acknowledgment made to the proper quarter. In this manner development is carried on by co-operation between ourselves and our customers. I do not know that there is any other point except that of individual motor-drives. Our machines are being designed to suit the new grid voltage, and naturally we do not want to have anything to do with belt drives or D.C. current. That, so far as our firm is concerned, comes straight from the horse's mouth. Regarding individual motor-drives, our present practice is to take individual motors direct to the unit to be driven instead of using one main motor and inter-connecting shafts and belts. Manufacturing and maintenance costs are thereby

reduced. One final point about coolant. We have found it highly desirable to filter the coolant to obtain the largest number of grindings per wheel dressing and in addition to this the finish of the work is perceptibly improved. Wheel dressing is reduced approximately one fifth.

MR. WRIGHT: With regard to surface broaching on small work, I can agree that it is a very good thing. Some of the large machines which surface broach all sides of a motor car at one pull, or a cylinder block, I think are going too far; but then you will have noticed that I am interested in milling, and milling is the conventional way of dealing with these surfaces, so I did not say very much about broaching. I have had no contact with these large machines at all, but I shall examine them with great interest when I have the opportunity.

Internal centreless grinding is quite interesting, but I have said very little about grinding. I had actually in my paper somewhere a reference to a method of controlling diameters in grinding, but now I seem to think I must have slipped it: but I had intended to speak about the fine control of dimensions in grinding by the photo-cell. I went on to say that for heavier cutting operations this could not possibly be used on account of deflections in the work and variations in the sharpness of the tools and distortions of the work-piece itself and certain other factors.

With regard to fine boring—I think that this is going to be much more used than at present. We are actually using fine boring very largely in machine tool work on the larger sides of bores, and we have made quite a number of machines for fine boring motor car cylinders, and it is one of those cases where the accuracy of the machine is not particularly reflected in the fine boring. The quality is all round about the bearing of the boring bar and the parts near it, and the rest is quite secondary.

Mr. Scaife supports me in reference to standardization generally. There are a lot of people believe you can make the Government pass a law to force everybody to do something or other. Well, laws are not passed that way. When a lot of people do something which is to everybody's good, and some people begin to object to it, then the Government makes it legal, and that is how Governments work. They do not do anything positive; they only prevent people from doing something they want to do which might be against the public interest. Standardization can be brought about in the same way. Production engineers, being the public in this case, will decide they want tolerances of alignment in any particular system, and all they have to do is to say in the inquiry, "Please state the tolerances of alignment in the machine you offer." You can compare them with any system you like, and it is either good enough or not good enough. But this alignment question may

be treated as Mr. Scaife says—if you ask a firm for the tolerances of alignment of the machine they offer, then they know from the beginning that it should be delivered those tolerances. But if you specify some tolerances of your own, or somebody else's which happen not to agree with the tolerances of the maker in some respects then it costs a lot of money to take a standard machine, to readjust it and refit it to certain other tolerances, though they may be better or worse. If you specify very fine tolerances it means taking down a machine and making a lot of extra work out of the general run.

I am glad that Mr. Scaife mentioned service, and the following up of machines by a qualified service man, but that is largely done I think. That is our practice, and I should think that most of the detailed changes which are made in the course of the life of a model arise from that source. The user has trouble, the service man comes to see him and finds what the trouble is and makes a report, and that leads to changes. We do not immediately dash round the shop and scrap everything, but we get the change in as soon as we can.

Mr. Scaife was talking very "1937" when he said that they will not have anything to do with D.C. Of course, Mr. Scaife's machines perhaps are more difficult to deal with by D.C., but five years ago if you told a machine tool maker that you were going to drive a machine tool with a windmill he would have made an attachment with a windmill on it. Now 1937 machine tool makers can say, "D.C.? We do not want the business." I may say that there are some machine tools in regular use which have need of a certain range of variation of speed in fine steps, and the Ward Leonard set is the thing that naturally suggests itself, amd that can be arranged to have the driving element of the A.C. or D.C. type. In fact, personally I think that ought to be used a great deal more. In cutting operations which are liable to be troublesome, material varies and things of that kind, it would often be quite a convenience if you could gradually change your speed 15 or 20% up or down without having to operate any gears at all, and the Ward Leonard set built into the machine would be much better than a lot of gear boxes and slamming of gears. I think that goes where a machine is built definitely for alternating currents motors and has to be installed in a D.C. shop, the use of a small rotary transformer is very often the easiest way to meet the case.

DR. ENGEL: I have to say a few words regarding the question of individual driving or operating driving machine tools. I think definitely that individual driving machine tools have an advantage. To start with, there is no question of its application for the type of machine where you have several motors necessary for the several works. Then with smaller machines, if you have a transmission

on your ceiling you are always dependent on the transmission rails. If you want to have a special line of production through your workshop you must have individual driving. I was in a workshop some time ago and saw one workman taking the parts from the machine of a preceding workman. They never had an independent press there.

MR. WRIGHT: I thank Dr. Engel for his confirmation of the idea which has, I think, been expressed. The individual drive does promote elasticity of arrangement of machines. The other point he mentioned also, that of the use of separate motors for the driving of the separate parts of the machine, is also one of very great convenience. This cuts out a lot of long straggling shafts and gear transmissions and all that kind of thing that we used to have years ago. The use of overhead shafts certainly interferes with the arrangement of machines. But in Birmingham for example, there are a lot of little shops making small details, which have been making these details for years and are likely to go on for years, where the arrangement of machines is not likely to be changed and is not of very great importance, and in a case such as this, group driving seems to be the solution; but when larger pieces have to be done there is no doubt that individual driving with the possibility of shifting machines about is the better solution.

A vote of thanks to Mr. Wright was cordially adopted.

Discussion, Leicester Section.

MR. M. H. TAYLOR (Chairman): I should like to ask Mr. Wright one or two questions. He has differentiated between progress and machine tool development; he has mentioned that, generally speaking, the machine tool development has to take the form of detailed improvement, rather than drastic change. I should be interested to know at what stage in our unfortunate series of "booms" and "slumps," he could consider it the right time to launch a product of drastically new design. It is tempting in the time of "boom" to put out the new designs, whereas it may very well be that the best time to put out such a machine is just at the time when orders for products which you have been supplying in the past are beginning to decline. I shall be interested to hear what Mr. Wrght has to say about this. I should also like to know whether Mr. Wright views with favour the greatly increased complication of the machine tools. Most of us, at the present time, are experiencing difficulty in getting skilled help, and it is often an advantage at times like this, to be able to take on new operators and train them on very simple single operations, and it may be at these times that the shop equipped with complicated expensive machine tools, which are easily damaged by unskilled people, is at a disadvantage in comparison with the concern which has specialised on a large number of simple single operation machines.

There has been a tendency lately to introduce ball and roller bearings in the milling machine spindles and I believe there is now a feeling on the part of a good many manufacturers that they introduced anti-friction bearings into such spindles rather too hurriedly, and some of them are reverting to their older practices. If anti-friction bearings are desirable, does Mr. Wright favour segregating the functions of radial and rotational thrust with ball bearings, or does he feel that the best method generally is to employ taper roller bearings?

MR. WRIGHT: Our Chairman has asked—"What is the best time to introduce a new design?" I do not know anybody who has found the best time! Usually, the machine tool trade is either satisfactorily picking up, and there is good demand for the normal products, or it is so very flat that the machine tool makers cannot afford to spend money on developments. They have to salve their consciences by developing new machines during slack periods but it is not easy to have machines put on the market when the slack period just presents itself, because during the "boom" they are too busy in the shop to bother building the experimental machines. The result is that the slump is well on top of them before they can

get the new models out and I should say that the more successful new machines are, in many cases, developed well into the middle of the slump ; when the slump has been running a year or eighteen months, when these new machines do get into the works you have got to get the trials over. If you are fortunate as a machine tool maker, you will have by that time, supplied one or two of these machines on loan, say for use in shops where the machines are of special interest ; those machines may run under observation. In the course of eighteen months or so the machine may be thought about for selling but it takes a lot of courage to put it on the market at this time. If the recovery from the slump is a slow gradual one, and there is good prospect of the improvement continuing, and becoming a good stabilised natural kind of market, then that is the best time for the machine tool maker to decide that he will put these machines into production and offer them.

There is a " boom " just now in the machine tool trade, which is very largely on account of shadow schemes and so on. I know quite a lot of machine tools reasonably up to date, which would have been on the market by now, or within the next few months, but which have been shelved because of the present rush for machine tools for the shadow factories, so that one cannot say which is the best time.

Regarding the question of complication. In my opinion there are two very distinct classes of machine tools, apart from the special machine tools. There is the simple production kind of machine which can be rigged up for a one cut operation, or perhaps a couple of tools will produce two dimensions at a time, and which can be run by semi-skilled labour. Then there is the general purpose machine, which you may regard as a tool room machine, and which is getting every day more and more complicated. For instance, some six or seven years ago the German lathe makers got together to agree on the specification and design of a standard lathe, which was to be made in various sizes, and the idea at the beginning was that this new specification should rather limit a lot of the elaboration that various firms were putting into their lathes, and should produce a rugged lathe with a range of speeds and capacities generally needed, but it should not be elaborate. When this lathe was actually on the market it was found to be as complicated as all the lathes put together. Every talking point that these firms had they insisted on getting into the specification. The result is that the lathe is a very complicated lathe. I daresay that by concentrating on a definite design, that the cost has not gone up as much as the complication, and is is probably a better bargain in as far as you are buying machine parts, although you are buying machine parts that are not going to be used ! I think that the way production engineers have influenced continuous production is bound to result, and I

think it is resulting now, in the production of machines with a very moderate range of facilities, suitable for a certain range of work, and simple in design, and such a class as that is going to increase very greatly, leaving more elaborate machines for tool room work, and general purpose work.

Regarding the question about milling machines and the use of ball roller bearings. We have tried ball bearings and plain roller bearings, and combinations of these with thrust bearing, and so on in milling machine spindles, but we do not seem to have been quite so successful with them as we have with the taper roller type of bearing. The spindle in the milling machine runs usually at quite moderate speeds compared with lathe speeds, and, on that account, the tendency to vibration in the drive is rather exaggerated, in addition to the fact that it is a milling machine with intermittent cut, but even with the use of taper roller bearings, it seems to be necessary to put quite a pre-load on them ; if you don't the spindle seems to be so sensitive in its bearings. It is much easier to put pre-load on to a taper roll bearing than it is on a roller and ball type, although the Skefko Company are now producing a roller bearing where you can slightly adjust the pre-load.

I think an important thing on the milling machine spindle is that the spindle should have bearings at three points in its length. On an ordinary milling machine you have a bearing at each end, but if you consider some 9 in. away from the front bearing is a milling cutter jagging away at the workpiece, you will appreciate that something should be done to increase the stiffness of the spindle and damp out any vibration. A third bearing greatly helps.

MR. COOKE : Regarding the picture we saw of the clamping device for a jig boring machine slide, I should have expected the head of the clamp bolt to be arranged so that the direction of the clamping forces was more nearly normal to the slide surfaces. It seems to me that, theoretically, anyhow, the arrangement shown would introduce some distortion. I should be pleased to have the lecturer's views as to what he considers to be the most suitable journal material to be used in conjunction with nitralloy spindles, and whether he considers differential expansion to be a serious factor with several materials of different characteristics in circumferential contact. Also, what is likely to be the minimum safe clearance in such a bearing, having reference to speed and lubrication? With regard to the use of small high speed gears in preference to larger heavier gears—what is the maximum safe pitch line velocity with high quality ground and lapped gears ?

MR. I. H. WRIGHT : In reference to the jig boring machine table

clamp, I agree that one might get into some argument about clamping forces. As Mr. Cooke suggests, these might easily be made perpendicular to the slide surface and that would apparently give pure clamping, but the clamp which is put on there is only operated by a short hand lever and the clamping force is consequently very small and so they get away with it. We have one of these machines and about five of the old ones in regular use, and this one is preferred in every way. I am sure that the clamping is not done savagely at all but on argument I think I should agree with Mr. Cooke.

Regarding the material I recommend for nitralloy spindles. We use a fairly hard phosphor bronze in connection with nitralloy conical bearings and machine spindles. We are using phosphor bronze because we have always used phosphor bronze for making a bearing. A very great deal depends on the surface finish of the spindle. In the old days this question of surface finish was more respected ; for instance, in reaming a hole for a bearing, the reamer should rotate in the hole in the same direction as the shaft was going to rotate, and when the shaft was finished in the lathe, or in the grinding machine, it must rotate in the lathe in the same direction it was ultimately going to rotate in the machine. That does not cover the case, but we are talking about general practice. The result of this was that we had very little trouble from seizing of bearings and that kind of thing, and I think if more attention was given to finish of surface, it would have a great influence on running of bearings.

Regarding the question of differential expansion. On these high-speed machines that are used now, it is often a slacking off in lubrication, not a real failure, but anything which allows the temperature rising from 60° to 80° in the bearing, which would easily occur, is very liable to cause trouble from differences of expansion. The result generally comes in bearings which are finely adjusted becoming tight by expansion, and causing a greater increase in temperature, or maybe the working out of locknuts, adjusting locknuts, and nuts of that kind. In respect to nitralloy spindles, and the phosphor bronze bearing, one would naturally think that when the bearing gets worn, the greater expansion of the phosphor bronze would increase the oil film thickness. This is what is really required to bring the temperature down and suit the higher speed conditions, but, as a matter of fact, the phosphor bronze is not free enough to expand. The phosphor bronze is usually pressed into a heavy housing which does not allow it to expand anything like what it wants to do ; in fact, I have known phosphor bronze bearings, which have been over-heated a few times, actually becoming loose in the bore in which they fit by continued compression of the material, by trying to expand them.

Differential expansion of the bronze bearing does not help as one would think it might.

Speaking about safe clearances. The safe minimum clearance at a certain speed is one resulting in about 40° temperature rise on the bearing, but to state it as an actual figure is very difficult indeed. But we have certain practices in connection with the milling machine taper spindles, nitralloy and phosphor bronze bearings. You can take the taper spindle, clean it thoroughly, and the bronze bearing thoroughly, put the spindle into the bearing. You then set endwise adjustment to bring it forward a couple of thou., or whatever you find necessary in connection with the taper of the spindle, which gives you a fairly good idea of the clearance for the oil film thickness you are going to get.

With regard to pitch line velocity in gears. I think it is a pretty general ruling that the pitch line velocity should be that they do not run over 1,200 ft. per min. That should be if you do your very best with the gears but there is no difficulty in running them up to 2,000. There are lots of ground gears running far faster than that in aeroplanes, but not so much in machine tools.

A VISITOR: Speaking about bearings, I would like to ask whether the lecturer can explain, or has any experience of, the Michel type bearing, and whether he knows the German bearing which is in use or application. It is used pretty extensively for thrust bearing but it can also be used for journal bearings.

MR. I. H. WRIGHT: I have not personally come across it. I did have, actually seven or eight years ago, a lot of technical information on the design of Michel bearings, with a view to trying to apply them to some fairly high-speed machines, but I found that the speeds that we were concerned with in milling machines were too low for the Michel type of bearing, also that the space occupied by such bearing round the spindle was generally very inconvenient, so I never actually tried them.

MR. W. FORD: I would like to ask Mr. Wright if lead bronze bearings have been tried in machine tools?

MR. I. H. WRIGHT: There has been some talk about lead bronze, but the objection which is raised by the people I have discussed it with, is that the loading in machine tool bearings is always very moderate. The size of the spindles are so large on account of other considerations of safeness, and reduction of distortion, and deflection, that the loading is not worth worrying about, and that white metal, the babbit class of metals, and so on, phosphor bronze, are quite good enough, and the very heavy loading suitable in connection with lead bronze does not seem to occur. Another reason, I think, is that lead bronze is best used very thin in bearings as it is not easy to make thick castings of it. This heavy loading capacity does not seem demanded. It might be all right in say grinding machine

bearings; I do not nowadays have much to do with grinding machine design.

MR. PLATT: Can Mr. Wright oblige by telling us anything about needle bearings? Has he had any experience of them?

MR. I. H. WRIGHT: Yes, we use quite a lot of them and so long as the load comes central to a needle bearing, it seems to be very satisfactory, but if the shaft is running on the needle bearings so that the load comes, to some extent, on the ends of the needles, rather than centrally loaded, there seems to be a possibility of the needles getting at cross purposes, and causing a little trouble. The needle bearings that we have used have been of foreign production, and they have been very successful, in about three cases out of four we have no trouble with them, but in the fourth case we may have trouble, but we continue to use them where there is definite need for a bearing occupying little radial space. The type of needle bearing which is made by the Hoffman Co., which has more substantial inner and outer races, is probably much better than these that we have been using. It is usually more expensive but I don't think that even that kind would be really good if there were any tilt on the bearing. There is nothing like a ball bearing for that, as it will stand a little tilt. I do not think a roller bearing is really good for that, but, in a general way, for heavy loads on a Press or heavy machine of that kind, where the crankshaft is well supported both sides, and the load comes central with the connecting rod, I think the needle bearings are really good.

MR. RADCLIFFE: I should like to ask Mr. Wright if he has had any experience of universal joints on high speed. Our lecturer may have some comment on the developments in materials in recent years, which have given a certain amount of aid to design. Has he anything to say about alloy iron, with particular reference to improving the life and size of screws, and that sort of thing?

MR. I. H. WRIGHT: In recent years I have rather come to the conclusion that it is a good idea to run universal joints at a comparatively high speed, if by so doing you are going to reduce the torque transmitted and universal joints at 600 are not running too fast, but if they are going to run so fast they must be fully enclosed, and in recent years we have been enclosing practically all the universal joints on our machines in a cover which absolutely keeps out dirt. Even when we have done so we have to be very careful in checking the universal joints; they have to be very well made, because the little "squirmy" action which occurs on the driving faces of the universal joints themselves is just about the worst motion in the world to lubricate. But we do use universal joints, as they are a convenience in connecting up two separate parts of a machine which are subject to relative movement.

The speaker mentions the use of alloy irons and other material

which influences the life of slides and screws. As far as the use of alloy irons to get greater life on slides is concerned, it cannot be done in the Machine tool trade, because the weight of the members, and importance of rigidity of the members from other points of view than weight, would make them prohibitive in cost. What is regularly done is to condense, or semi-chill, the surfaces which are going to form the slides, and it is not uncommon now to get a Brinell number for the slide surface on something over 200, which is pretty good for cast iron. Now that slides are ground, of course, we are much less dependent on softness. We are a good deal ahead of twenty years ago when all slides were scraped by hand.

With regard to the life of screws ; I believe you have in mind the hardening and grinding of guide screws of lathes. I do not say it is a physical impossibility to do so, but on certain machines involving a screw about 1½ in. diameter, and 3 ft. long on the thread, we thought it would be nice to have them hardened and ground, or at any rate to think about it, and we sent several inquiries to the best firms we knew of, and the price of these screws was £60 each when ordered 12 at a time, so we do not go in for the hardened and ground screws ! We do the very best we can by milling the thread in the screws. Then we finish this one side at a time in the lathe, so that we get as far as we can on the size of the screws, the kind of surface that is suitable for carrying load. We make the bronze nuts long, and tap them with a very long ground thread tap.

VISITOR : With regard to damping out oscillation by means of the flywheel, which is shown on the milling machine. It seems to me that that would set up enormous stresses in the gears, and therefore, to overcome the effects of the periodocity vibration, which Mr. Wright must know are enormous, they must design and build their gears at a very excessive margin of strength and size. It also appears to me that the whole of the machine tools that have been shown here were very nice, and that we are now producing more or less a very elaborate lot of machines, whilst we are not improving at the same ratio, absolutely the prime mover, that is the milling cutter, or the twist drill. Can Mr. Wright tell us if the design of the milling cutter has been changed to overcome this vibration and also can Mr. Wright let us know if there has been any development particularly in the design of drills, or the driving of drills, bearing in mind that the drill is considered to be the most uneconomical tool in use ?

MR. I. H. WRIGHT : With respect to the flywheels ; admittedly, the flywheel produces shocks. For instance, when an edge of the milling cutter is starting in to a big chip, at that instant it wants to slow down, and the flywheel won't let it. The flywheel has got to drive the cutter into that chip ; without a flywheel the spindle and shafts would wind up like a spring and shoot the chip out like

a spring. If you have a damping device like the flywheel, the variations are less at the driving gears than they are at the milling cutter, so that though the milling cutter, admittedly, is subject itself to heavier loads, it avoids the hammering effect of backlash in the driving gearing.

In the case of the machine shown with a big flywheel ; the spindle is driven by a big worm wheel and a highly efficient worm. The shaft that carries the worm is so light that if it wants to vary in speed it can do so with little shock ; there is no heavy gearing attached to it. In a general way those machines have the reputation of being very sweet cutting machines.

The gentleman also speaks about elaborate machines. If I had time I would show you about half of those illustrated which are really simpler than the machines that were made about ten or fifteen years ago. The use of motors has done a great deal towards simplifying them. It is the high-speed machines where the motor has cut out a tremendous amount of trouble, and high-speed details which were too small.

Regarding tool improvement ; there has been a certain amount of tool improvement in milling cutters, but it has not been kept up so vigorously in recent years.

With regard to the twist drill ; I consider that the present stage of the twist drill is one of the finest testimonials to the work that has been done in tool development by both machine and cutting tool manufacturers, that we have. If you begin to think what a twist drill has to do, and the stress it has to bear, and the rates of penetration you can get on various materials, we must respect the twist drill, and I have no hope of suggesting any improvements—I could not suggest any line in which progress could be made. Personally, I think that the flutes of twist drills should be chromium plated. I am interested in the subject, and have been concerned with twist drills for quite a long time. My opinion is that when the twist drill, which itself is steel, separates the chip from the work, that that chip coming away, also steel, is in a condition to seize on to any steel surface with which it comes in contact and as it is ribbing over the surface of the twist drill flute, it is very liable to stick there. I think if you chromium plated the flutes of the twist drill that the steel would then be running over a surface which is not steel, and would be less likely to seize and clog the drill.

VISITOR : Regarding the down cut milling machine ; one would expect more production with this method in relation to the better work produced. Also on turning machines for small shafts. Does Mr. Wright consider a single tool on very high speeds is more suitable from the production point of view ?

MR. I. H. WRIGHT: The down cut milling machine has its uses, and I say that for flat pieces that can be laid flat on the table and be milled that way, it is a very interesting proposition, but there is no type of milling machine that is best for everything, and the tendency I think, in connection with this one is to claim too wide a field for it. The method has certain interesting features, and certainly produces a good finish and accuracy on suitable work.

Regarding the question of the high-speed lathe with a single cutter, rather than the lathe not quite so high-speed with a multiple tool set-up. The high-speed lathe with a single cutter, of course, is using tungsten carbide cutter, or some cutter like that. I think the reason that people usually first get that experience with a single tool of tungsten carbide, is that unless the conditions are understood, it is very easy to have trouble with these tools snipping, and things of that kind, and for that reason, a multiple tool set-up would be a setting-up job, rather than a production job. If the machine is really suitable for the use of tungsten carbide, and the conditions which have to be observed in safely using tungsten carbide are better known, the possibilities of using two or three tungsten carbide cutters in a set-up will be much better than they were, say two years ago, so that although the single cutter method is good in the earlier stages, the tendency will be to use multiple tool set-ups, although probably never to quite the extent we do in the case of high-speed steel, but there is no doubt that the single point tool, as used on the Magdeburg chip flow lathe in connection with length and diameter stops, is quite a production job and has the advantage that a single cut produces less work distortion than a multiple tool set-up.

OVERHEADS.

Paper presented to the Institution, Manchester Section, by W. Walker.

Preamble.

WHEN I accepted your invitation to speak on the subject of "overheads" I realised that I was undertaking a considerable task. I also realised that four courses were open to me as to how the subject should be dealt with, namely, (1) to deal with the subject more from the point of view of text-book theories; (2) to deal with it from a costing aspect and spend time on explaining how overheads are, or are not, allocated, as the case may be; (3) to deal at length with the system which I have had the opportunity of knowing for a considerable time; (4) to raise a number of questions to show that the terms used are in need of more exact definition, and out of the development of these points, to glean information not only for myself but to help you in arriving at your own conclusions. Having given further thought to each of these courses, I felt that the best service I could render to your Institution would be to over-emphasise rather than to under-emphasise the last course, and to deal more sketchily with the first three. It is obvious that in the time available it is not possible to deal with each of the courses at great length.

The Importance of Overhead.

It is not possible to overstate the importance of overhead in the success or failure of any commercial enterprise. The proportion of overhead in total cost can either be too high or too low, and failure to readjust foreshadows danger if not disaster. Overhead is sometimes a higher proportion than all the other elements of cost put together and, therefore, if for no other reason, it is very necessary to have a clear conception as to what is a suitable proportion to ensure that overhead not only maintains a good standard of efficiency, but that it also supplies its quota to the business success. Unfortunately, however, overhead is the least understood of any of the elements of cost.

Difficulty of Exact Definition.

Anyone who has given thought to the question, and has had an opportunity of discussing it, will, at first acquaintance, have been

amazed at the absence of a clear line of demarcation. Usually, a cost is spoken of under three main elements—material, wages, and overhead, but I have yet to find a universally workable definition that is of much assistance in everyday business life.

It would appear that material is the easiest item to define. In practice, however, we find that there is material for the manufacture of saleable product, and there is also material for maintenance of equipment, i.e., repairs, etc. Sometimes material is spoken of as meaning all material, no matter for what purpose it is used, and at other times it is spoken of as material included in the saleable product, and the material for repairs, etc., is included in overheads. Later on, under the heading of " Examples of cost types " I shall have more to say on the subject of material.

Similarly with wages. The simplest definition is that it is *direct* operators' wages only, but again I have yet to find a workable definition which will clearly state when, say, a toolsetter ceases to be a direct operator and becomes indirect wages. Thus, there are very many definitions of wages. At one end of the scale we get the bare operators' wages only, and at the other end wages include the operator, the setter, the inspector, the foreman, and some service labour such as store-keepers, etc.

Coming now to the element of overhead, one definition I have heard is that overhead is " that element of cost which it is not convenient and/or practicable to allocate directly to any specific item of product." Hence, we arrive at the point where none of the three main elements of cost have been clearly defined, but leading up to the view that convenience and practice play a big part in determining what is called material, or wages, and what is called overhead.

Definition is Dependent on Accounting Structure.

In some types of business it is conceivable that it is both convenient and practicable to allocate say, draughtsmen's or production engineers' wages to a specific item of product, but these, I suggest, are the exceptional cases, and costs are only one kind of financial statement that are prepared for the guidance and control of business. Most well-managed businesses of to-day get out their financial statements at relatively short intervals and are not content to wait until the close of the year. This has led to an improvement in the technique of preparing, displaying, and presenting these financial statements, and in many cases the preparing of individual costs has taken somewhat secondary place, the costs themselves being used as supplementary to the main financial statements.

The position of affairs being what it is, it becomes clear that however the financial statements display the expenses of a business, so the costs must likewise display them under the same general

headings. In other words, what is called overhead on a financial statement is, or should be, called overhead in a cost. So we arrive at the position that if we can clearly specify on the financial statements the items which are intended to be called overhead, they must be the same items as are called overhead in the cost, and, further, the items which are called overhead on the financial statements, are dependent on the accounting structure.

It is a well-recognised basic principle that the accounting structure must follow the lines and development of an organisation, and not the organisation follow the accounting structure. Thus, it is apparent that any well-conceived accounting system must have had due regard to the organisation and the product manufactured in that organisation. Type of product does demand a type of organisation which, in turn, influences the accounting structure, and governs the cost definitions, and I suggest that we leave clearer definition at this point, until we have examined examples of cost types, organisation types, and product types.

Cost Types.

It is no exaggeration to say that there are hundreds of cost types in operation in this and other countries. This is in no sense a criticism that these cost types are not necessary, because one would hesitate to make such a statement until the nature of the problem was more clearly understood. It is suggested, however, that these hundreds of cost types could be reduced to fewer types which could be clearly recognised, with minor variations classified as sub-divisions.

Organisation Types.

Of three organisation types, the traditional, the semi-functional, and the functional, *the traditional type* is usually found where the organisation is small. It may, however, occasionally be found where the organisation is large. A moment's thought will show that in every business all the functions of management are being performed. The difference between this type and *the functional* is that the duties assigned to various individuals are a collection of functions. For instance, the head of a small concern may be the managing director, the works director, the sales director, accountant, and secretary—all in one, and he may have difficulty in deciding at any moment which of his functions he is performing.

In larger organisations these separate functions are usually allocated to separate individuals and are then not difficult to recognise. What *is* more difficult to decide is the point at which it is profitable to allocate the functions to separate individuals, as the whole art of organising a business is to obtain the best from the means available, both human and mechanical. Therefore, before any appointment is made to these functions, there should be fore-

seen a corresponding saving elsewhere. That is to say, if a separate appointment is made, incurring a kind of expense not previously recognised, then some other function should be performed so much better, or work should be done so much more quickly, that the sum total of the combined result shows an improvement. To bring out this latter even more clearly : it does not seriously matter whether the expense of an organisation is contained in the direct or the indirect cost of production, provided the sum total is economic, and as the modern tendency is a continuous march towards mechanisation of processes, etc., it inevitably follows that a larger and larger share of the total cost comes under what is loosely called " overheads."

I hold the belief that there are ten or eleven functions which are common to all business, whatever its nature. Agreement has not been reached on these or on the order of their importance, but I believe they are : Finance, employment, plant, production, inspection, planning, stores, development, design, merchandising, selling.

I further believe that each one is contained in a subordinate degree in each of the other functions, that is to say, it is impossible to consider any one without considering also its effect on the others. This interconnection makes it very difficult to explain or appreciate, but I think it is easy to see that a very chaotic condition would result if this interconnection did not exist.

Of the different types or stages of organisation, one is where the head himself performs all the functions. There is little in the management beyond himself, the drive and whole success depending on him ; if he fails, the whole fails. This type is usually found in businesses of a size of, say, up to 300 employees, not more.

The next type is where the head assigns some of the functions, and carries on up to, say, 600 employees' size. The next is where the functions are still further assigned, and this type will hold, with little modification, whatever the size of organisation.

The point I want to leave clearly in your thoughts is that every business does, in fact, conform to this latter type, although one individual may perform many duties and functions, and this fact very often obscures this very fundamental principle.

Product Types.

There are two broad types, with an intermediate class which is not very easily defined. At the one end of the scale is the true mass production article where there is continuity of production of some article for considerable stretches of time, all exactly to the same dimensions, pattern, etc. At the other end of the scale is the individual job production, which usually is not and need not be identical to anything done before. The intermediate " batch " class is usually

produced in larger quantities than the job class, and in some respects may conform to patterns of a previous job but cannot strictly be described as coming under the job or the mass class.

Any of these classes may carry a degree of complication quite different to another. That is to say, in the job class we may get a product which is of the simplest nature and requires little of any kind of service behind it, and also in the same class may find a product which requires the very highest service behind it, and similarly throughout the classes.

The fact of a product being classified under mass, "batch," or job, is not in itself a sufficiently close description to enable the type of organisation to be assumed. Some indication of the degree of its complexity is also necessary.

Under the heading of complexity is the question of designing, patterns, and patent rights, development, and technical evolution, stocking and selling with their thousand-and-one aspects. Each of these classes of service varies in its degree. Take design and development, for example. They may be concerned with the product only or with the tools and equipment which make the product. If the product is simple and the tools simple, then the design charge would usually be a small proportion of the cost, but as soon as development is required and evolution either in the product or the processes takes place, then the factor of design becomes a greater proportion.

Selling is too vast a subject to do more than merely mention, except to say that salesmen are expensive, require careful training and nurturing, and even then, unless supported by service and quality, cannot succeed for long. Delivery also is fast becoming a most important feature of service. To meet delivery requirements some kind of stock policy must be formulated. More and more the customer is expecting the supplier to speed up delivery and in many cases is forcing him to carry stock to meet—not firm orders, but loosely indicated requirements. This carrying of stock by the supplier is accentuating what is called the stocking and seasonal variation problem.

The point I am striving to emphasise is that to merely describe the product as job is insufficient. The degree of service, its selling and stocking problems, also require to be stated. The job product can be simple or it can be difficult; the "batch" product can be simple or difficult; and the mass product can be simple or difficult.

Classification of Organisation and Product Features.

For many years I have felt there is a real need for some classification plan which will enable the features of organisation and product to be indicated with reasonable clarity, such information to be used by the executive in the same way that the motorist uses a road map and the mariner uses his charts and compasses.

Far too often the essential features of a business are misrepresented and much needless discussion takes place, due, I believe, to the absence of a plan or chart.

In the course of my experience I have had many opportunities of visiting other businesses and looking into their accounting problems, and I have found that the simplest way—at any rate for me—to get a true conception of their problem is to mentally classify the organisation on a plan that I will describe. Apart from these visits, there have been many occasions when I have had the pleasure of explaining the particular system which is in operation in the business with which I am connected. On these occasions I have sometimes formed the impression that, because our system is somewhat unusual, the visitor thought it would not be suitable for his business and therefore he made no attempt to understand our problems or background conditions which had, in fact, determined the structure of our organisation and accounting system.

Take a diagram divided vertically into three main fields: The *organisation*, the *product*, and *the cost proportions*, with further vertical sub-divisions of each. These latter I call "features" and give them numbers. Horizontally along the top are degree numbers, and the general idea is that each of these features should be charted according to the degree number. With such information before one, it is relatively simple to understand the salient features or background conditions of the particular business; and surely it is more satisfactory to understand and then criticise the system under which a business is operated, than to remain in ignorance as to why this or that method has been adopted.

Dealing with feature No. 1, that is, the *Organisation Type*, the sub-divisions here will be what have already been discussed. The traditional organisation type, with functional duties completely merged, will be degree No. 1; roughly half-way along the diagram will be the functional duties partly separated (degree No. 4); and towards the end of the diagram will be the functional duties completely separated (degree No. 8).

About 300 is the maximum that the traditional system with the functional duties completely merged will stand, for the reason that under this type of organisation the whole drive and energy, success or failure, is usually determined by the energy and foresight of one individual. Above this size it is not to be expected that one individual will be able to supply virtually the whole galvanising force to an organisation.

Under the second main heading—*Product*—will be the three stages of job, "batch," and mass. Job will be towards the left of the diagram, i.e., a low degree number; and mass towards the end of the diagram, under a high degree number. It is not usual to find these clear lines of demarcation—within the same business

may be found a certain amount of jobbing, "batch," and mass work; but in the charting under degree number the relative importance will be averaged out and stated, as the accounting system will obviously place more importance on the highest proportion of type of manufacture.

Features such as design and development, selling, and service will be under degree numbers as percentages of total expense or cost; stocking under number of investment periods in relation to average turnover; and seasonal variation as a percentage of average sales.

To recapitulate, then. Under the mass type of manufacture one would expect a fairly high proportion of selling, servicing, stocking, and seasonal variation: under the jobbing type, one would expect to find selling and stocking relatively light.

Dealing with the third main heading—*Cost Proportions:* these are further sub-divided into material, wages, and overhead; and the degree numbers start in each case with the lowest proportion and work up to the very high proportions, the sum of the three main elements building up to 100%.

The idea under this form of display is to show whether a problem is one connected with material, with wages, or with overhead. For instance, if the material and wage proportions are relatively small, say together not more than 50%, and overhead accounts for at least 60%, it is obvious where the greatest savings can be obtained, either by improving the efficiency of overhead, or by increased volume which reduces the amount of overhead per unit more quickly than any other method. If, on the other hand, the overhead is relatively small and there are high proportions in material and wages together, then the greatest savings are open by an intensive study of these two elements.

With a diagram correctly filled in as regards organisation and product features, experience has proved that the cost proportions are not difficult to imagine, and departures from these are usually a very fruitful source of investigation. In fact, it has been found in practice that comparisons made entirely on the basis of such a diagram have frequently led either to considerable savings or improvement in efficiency with their consequent effect on the profit position.

(*Here the author gave an explanation, illustrated by diagrams, of the system in operation in the firm with which he is connected.*)

Determination of Overhead.

How to determine the amount required to run efficiently any department or division of an organisation necessitates much investigation and knowledge of the business requirements. It is not too much to state that almost as many businesses have difficulties

due to an insufficient allowance as due to an excessive allowance.

The general lines on which this determination may be approached are : (*a*) By ensuring that the organisation as a whole is in reasonable balance and that each section is being operated on an economic and efficient allowance, and (*b*) by reference to the past records of the business, as well as to comparisons which can be made as and between one business and another, which will broadly enable the overhead to be provisionally determined at least.

It is little use attempting to fix allowance for an overhead department without reference to the complete budget, as only in this way is it possible to obtain a true perspective.

The financial side of the organisation and/or the budget officer has usually developed a series of standards which do enable a suggested figure to be put forward and, by means of a budget questionnaire, the claims of the various departments can be shown alongside the series of standards, and from these it is not too much to expect that a figure with a fair amount of accuracy has been arrived at. Once ascertained, the figure will serve as a very excellent standard for present as well as future requirements, care being taken to adjust it as the load or level of the work within each of the departments rises or falls.

The proportions of fixed and variable expenses should be very carefully considered because, if the business is one which is subject to more than the average expansion or contraction, it is usually advantageous to sacrifice (at least on paper) some small amount of efficiency arising from a high degree of mechanisation in order to have flexibility in adjusting the expense allowance when the business contracts.

From my own knowledge, it is possible to convert these adjusting figures for the rises or falls, based on an understanding of the proportions of fixed and variable, in such a way as to leave the final answer subject to very little challenge, and it is this knowledge and experience which have played such a big part in the accurate compilation of a budget.

Control of Overhead.

The control of overhead expenses should, I believe, be exercised in every case on a budget basis, and from the accounting forms previously described, you will note that we have this plan in operation. If, alongisde the actual, is shown the budget which was arrived at after careful consideration of a balanced organisation and the claims of the respective departments, and also the actual of a previous year—all these displayed line by line so that some responsible official is called on to answer for departures—it is surprising the effect that this has in keeping the figures in correct proportions.

I have assumed that from time to time an efficiency investigation

is made into the methods of operating every department, with a view to taking advantage of the improvements which are possible by the use of the right grade of labour and equipment.

I understand it is quite a popular opinion that the efficiency of, say, a production department is much higher than the efficiency in, say, an overhead or office department. This view may or may not have arisen from the fact that the proportions of overhead to the total cost or expense have in many cases tended to get greater and greater. The opinion may still be true in a number of cases, but, broadly, I believe it is quite untrue, as there has been as much development in office methods and attempts to keep overhead expenses in proper balance in later years as there has been in production departments. The methods of improving efficiency are the same whatever the department, and if you will recall what I said about the inter-connection of functions you will, I feel, arrive at very much the same conclusion. The proportions of overhead are, or should be, governed by the background conditions of the business, and should not be allowed to increase in an arbitrary manner regardless of these background conditions and the real business needs.

Apportionment.

Except in the very simplest of businesses, having only one line and size of product, apportionment is admittedly controversial and difficult. There are two schools of thought, one which says that, because it is so controversial and difficult, no very useful purpose is served by apportioning overheads, and the other which says that it is absolutely essential to get a correct perspective of the profitability of the several lines, and that overheads must be apportioned to each main line of product as the barest minimum, and even so far as to the individual items of cost.

Personally, I take the stand that overheads must be apportioned to the respective groups of products on as accurate a basis as is possible. The difficulties, and the elaboration needed successfully to apportion on an accurate basis, should not be allowed to interfere or hinder the correct presentation of the facts. I know that overhead is difficult, and I know that it cannot be dealt with on such a simple basis as a percentage on wages or on material. It requires more accurate treatment than that.

Many of these overhead expenses have no positive relationship to either material or wages, and to get the proper accuracy they need to be dealt with on a series of bases other than the material and wages. For example, design may require special treatment, either on a basis of the actual expense (if it can be obtained) or on a rate specially constructed on, say, so much per order or so much per quantity unit. I know too, that selling may require a separate rate such as, so much for the order, which may cover several part-

deliveries, so much per invoice, so much as a publicity charge, so much as a general charge, and so much for packing charges. It is often overlooked that overheads bear little, if any, relationship to materials and wages.

On several occasions I have made the statement to a body of cost accountants that, where the overhead proportion is high, if I am given an accurate apportionment of overheads to the item, I will find the direct wages by reference to the material and overhead. Needless to say, this statement appears very revolutionary and has led to much argument and comment.

A Basis for Apportionment.

As a result of cost accountancy research, experiment, and experience, the following rules have been evolved for our own guidance :

(1) Overhead should be stated department by department as an amount of money per period, per half-year, or year, apportioned to broad product groups on a series of indicators.

(2) The indicators must be selected as the best measure of how each department does, in fact, spend its expenses product by product. There is as yet no golden rule as to which indicators best measure the facts pertaining to each department ; sometimes a combination of indicators, suitably weighted or influenced, is found to be more satisfactory than a single indicator, bearing in mind that we are trying to find a better basis for apportioning overheads than as a percentage of material or wages or both. It is not claimed that all these indicators will be universally applicable though many of them are ; but they point the way to a method which has been tried and tested.

(3) When the overhead has been allocated to products in amounts of money, it can then be re-expressed in the form of a scale of oncosts as percentages of producing cost.

(4) A further refinement to an all-in percentage of producing cost is to express the percentage as a varying one on the elements of producing cost, viz., x% on material, y% on wages, z% on depreciation and supplies (i.e., machinery and plant depreciation, tool consumption, and power and shop supplies).

This method has the advantage of almost indisputable accuracy as regards the overall facts product by product, and great costing simplicity of individual items within each product.

Just a word of caution : costs are not always accurately compiled, and it is not always appreciated that there are many stages or levels of costs. For instance, when a simple or compound percentage is adopted, the limitation of applicability is not clearly recognised. The standard (simple or compound) percentage plan may be quite suitable for an average or true-to-type item within a product group, but is often quite inaccurate for major fluctuations from the average or true-to-type.

Further, the *amount* of many items of overhead does not appreciably change because an odd operation has been changed, say, from a bench to a machine, or vice versa ; neither does it change because of a minor change in load or level of activity. Therefore, beware of using costs for a purpose for which they were not intended. Know the appropriate level of cost (i.e., which elements of cost to include for the particular purpose in hand) and do not use that level again unless it is for precisely the same purpose.

Summary.

Mention has been made of :—

Importance of Overhead.—Beware of proportions which are not in correct relationship for the requirements of the business.

Difficulty of Exact Definition.—Overhead not yet defined on a universally workable basis. It depends on the accounting structure which in turn, depends on the organisation and product (i.e., background conditions).

Cost Types.—Suggested that these should be classified into a few basic main types, with decimal sub-divisions for minor variations.

Organisation and Product Types.—Traditional, semi-functional, and functional : job, " batch," and mass.

Classification System for major background conditions.

Method of displaying and explanation of a well proved and satisfactory accounting structure which clearly specifies the overhead contents.

Determination and control of overhead by standards.—Budget questionnaire and clear display of actual, with comprisons alongside. Factors of fixed and variable proportions have bearing on fluctuations of levels of activity.

Method of apportionment.—Elaborate series of indicators applied to apportioned amount of expenses, and not a slavish following of direct expenses as a basis.

Re-expression of apportioned amount on percentage basis.

Use and misuse of costs.—Recognise limitation of applicability and different cost levels.

Discussion.

MR. J. WALLER: I am afraid after what we have heard that there is not much left to discuss—at least theoretically.

At the outset I must make it quite clear that my training and experience have allowed me to believe that Ridgway, Lunt, and Bigg—amongst the greatest exponents of costs and allied work, have each advocated simplicity of system and economy of method as being the underlying principles of recording costs and overheads. The lecturer has shown us, indeed, a good system, but I would suggest it is an elaborate system and not in conformity with the above views. In my opinion we have not had a very clear description of "overheads."

Personally, I have always tried to look upon "overheads" alphabetically, governed by those letters contained in the word "overheads" i.e., O—ORGANISATION (without organisation "overheads" cannot be presented in clear terms), V—VADE MECUM ("overheads" should always be the "all in all" of the cost accountant), E—ECONOMY (if the method of recording "overheads" is expensive, then the resulting figures appear to have lost some strength in argument), R—RATIONAL ("overheads" must be endowed with reason), H—HOMOGENEITY (no matter what constituents "overheads" contain they must all be collected in the same way), E—ELEMENTAL (having gained all the above objectives, they must be based on the first principles), A—AUTHENTICITY ("overheads" must, of course, possess the quality of being authentic), D—DEMARCATION (I think you will agree that it is necessary to know where to draw the line), S—SUBSTANTIATION (the final letter and a very important factor in "overheads").

The lecturer has stated that it is possible to find the same background in industries so wide apart as toffee, bricks, and engineering. From a varied experience, I would suggest that this is improbable. I would even go so far as to state that efficiency methods are sometimes responsible for incorrect "overheads." Let me give you an instance. Suppose a workman has a large piece of steel plate issued to him from some material section in which department, preliminary operations, taking twenty minutes, have been carried out. This workman has only ten minutes left to complete the job. In this case ten minutes only is booked as direct labour. Hypothetically, at 5s. an hour, ten minutes at 200% "overheads" is equal to 2s. 6d., whereas, if the job had all the labour booked as a direct charge the value would have been 7s. 6d.

I am opposed to the term "overheads" because each person connected with this branch of costing belongs to a different school of thought. On my own part, I would recommend the adoption of "expense factors" so that when comparing "overheads" between different firms—machine shop expenses, fitting shop expenses, and so on, are synonymous terms, over which a great deal of haggling might be avoided.

In conclusion, I would like to say that the first and last letters of my alphabet—O for organisation and S for substantiation—are the most important elements in "overheads" and with these two points in mind efficient scales of "overheads" should obtain.

MR. WALKER: The illustration you quote about sheet metal is an old favourite. I know the story and it is quite true. I would remind you of my warning that costs are not always accurately compiled. You do really find that, when the wrong cost system is used, inaccurate results are represented as correct results, but training and experience very quickly eradicate the more obvious of these. I quite agree with Mr. Waller that the computed answer was not correct.

Regarding the point of three manufactures such as engineering, toffee, and bricks, having the same background, I believe I said that you *could* and in fact did find the same background conditions in industries which were very wide apart. The distinction I was making was between uniformity of costing by the same background conditions and uniformity of costing within the same industry having totally different backgrounds.

MR. POWER: Mr. Walker said the organisation is before the cost structure. I think he ought to explain this further, because one has some vivid recollections of what happens with a very aggressive type of cost accountant in a new works. He comes in with a big brush, introduces new rules and regulations, and eventually becomes the works manager. He disturbs the organisation but finally it settles itself down again, probably on the lines of budget control, standard costs, etc. We can call ourselves production engineers or anything else we like, but *they* have the whip. Mr. Walker has not talked to you like that, but that is what occurs.

Regarding the adjustment of cost standards where the load varies, I cannot believe anything is standard where it varies seriously. Mr. Walker talks about adjusting cost standards. He ought to tell us more about this and how budgets are prepared and operated. Incidentally, a lot of data from which budgets are prepared is not prepared by cost accountants, but is built up from data somebody else prepares! If the information is wrong, the result is wrong.

Regarding efficiency of office departments, I agree entirely with Mr. Walker that as much attention should be given to any office departments as is given to works departments. This is absolutely

necessary because they do get themselves into bad odour by looking very miserable and walking round the shop with a bit of paper in their hands and looking very important, and they could not convince the people in the works that they were efficient and they were not, that was the point! They have been forced to become efficient!

Another point Mr. Walker talked about was background. Well, personally, I know a lot about background. I think Mr. Walker means a type of organisation and the kind of service within that organisation. I entirely agree with him where the services to the operator are highly developed. Labour cost would be low but the service cost high, and in accordance with where you put those service costs so will your overheads be very high or low. This is determined largely by the management type of control. People say, " Look at the overheads—200%," but it might be just a source of profit. You need never be frightened by overheads when you know what the overhead is.

Mr. Walker might have mentioned where cost data should be originated. I would say very definitely that your cost will not be good unless your cost man works in the works, because such a cost man is half a cost accountant and half a mechanic, and I contend that the information the central cost office has to have should come from the cost man who is out on the floor in the shop, because he gets the instinct of the shop and the co-operation of the shop.

MR. WALKER: I should like first of all to acknowledge the debt I owe to Mr. Power who has always been a scathing critic, but from that criticism I believe I have profited far more than can be expressed. Mr. Power, as usual, has raised in the short time he was speaking as many points as would take up the whole of your syllabus for the next five years! The first point he raised is my statement that the cost accounting system should follow the lines of the organisation and not the lines of the organisation be made to follow the cost accounting system. The lines of the organisation may be good or bad. On the one hand, some changes may have been prompted among other desires to obtain improved overall efficiency and financial accuracy, but, on the other hand, these changes may have had minor disadvantages which are more than offset by the advantages. A cost accountant might be able to influence the lines of the organisation, but in that sense he is acting as adviser to someone who is making the decision; and he, himself, is not the one to make the decision to change the organisation to suit the accountant.

Mr. Power also said that a cost standard should be a standard through thick and thin; there should be no adjusting of a standard. I believe I was principally speaking of adjusting the figure for an overhead department; at least that was my intention. I was making the point that if one knew the proportions of fixed and variable

expenses (and it is surprising how much knowledge one accumulates on this subject), the fixing of the budget figures for varying loads of business is easily possible so that the actual expense will be very close to the budget.

Another question is, whether or not one should frequently adjust a production cost standard. This is very debatable, and I think rather too big a subject for me to open out on to-night. There are reasons for and against, but I take the view that these standards should not be adjusted too frequently.

Another interesting point Mr. Power made was something on the lines that the cost accountant does not initiate the figures he puts down. A cost accountant above all things should be tactful, and if he can get the person consulted to put down what he (the cost accountant) knows to be right, he has no need to challenge it. Life is a lot smoother and easier by letting the other man have his own way. Very often the cost accountant has already fixed the figure reasonably closely but, other things being equal, it is better for the works manager to have his say and for the cost accountant to be very tactful and leave him to give the figure required : then the works manager carries the responsibility !

Now Mr. Pucknell supported me in my contention that efficient standards should be set for all sections of the organisation. I hope some of you will challenge this statement. In a well organised office department there is usually as much opportunity for applying efficiency methods and all that they imply as ever there is in the production departments. In my own sphere I am just as much a production engineer as you are out in the shop.

Mr. Power mentioned the term " producing costs." In the paper, I said that it did not seriously matter whether the cost was the direct or the indirect provided the total was economic. Mr. Power meant the same thing. You start off with the problem of men working single machines, with very little service to assist them, i.e., a low departmental overhead : then a few men operating many machines but requiring more departmental services, i.e., a high department overhead. What is the producing cost in these two cases ? It is service as well as operator ; at any rate that is the line I take.

A final point was accuracy of costs—whether the accuracy of a cost is based upon having the results compiled in an office or in the shops. This is an old argument, and the point of view I take is this : That on balance it is a very near thing, providing you get somebody (whether he be in the office or in the shop) who understands shop processes and has an appreciation of all that they mean, and I am prepared to admit that one gets that intuitive feeling of whether the result is correct more quickly by being alongside the job. That, however, is not the only way to prove correctness, but I am afraid we shall have to leave it at that.

MR. CROOKE : I think we will all agree this evening that the whole subject of " overheads " is very complex, and as a man in the works I am finding it a little difficult to express what I have in mind. Until this evening I really wondered whether the cost accountant was a magician or an expert " wangler." Without being facetious I am rather inclined to the latter theory. You can have your budget and you can have your previous year's figures as a guide, but it occurs to me that in organisations where they have complexity of production you can be let down immediately if you pay any attention to the previous year's figures, which I believe Mr. Walker has referred to on several occasions, because the results which you wish to obtain are obviously influenced by such incidentals as increased wages due to various causes, and quite a number of minor items which really become very serious when you are concerned with production. I would mention one curious example. We have a piece-work going through the works which usually takes six to eight hours for a particular operation. Owing to change in design that particular part has been altered in its material. I do not know whether there are experts in this proposition I am talking about, but we find that one piece may taken fifteen hours against the original six or eight. In another case you are lucky if you get it off in thirty hours. That is totally out of the scope of the man who is doing the job. He can be an expert and still have a variation of fifteen hours on one piece.

MR. WALKER : There are some variations which are inevitable. What I was implying was that with a budget, and with a previous year's figure set alongside the actual figures of the current year, you were in a position to note departures and to take proper action. The example which Mr. Crooke has given me would show up in the producing cost which would show an excessive cost measure against a predetermined standard. Surely the standard should be set on the assumption of getting the right kind and size of material ! But if there has been change in the design, then that change should have caused a fresh standard to be determined. There will be departures from time to time between actual standards, and these departures provide the opportunity for appropriate action to be taken to see that the cause of the trouble is removed. The man on the job would know all about the trouble but it is the management who are responsible for producing efficiently, and so standards are set to inform them that something requires attention.

MR. H. G. KING (Section President, who presided) : I quite agree that a production engineer is not necessarily a man who is merely producing articles of metal or whatever they may be in the shop. The cost accountant is producing for our use in the works, costs which should be simple so that we, as works managers, or

departmental heads, or even foremen, can readily grasp what is at the back of those costs.

The paper to-night has been to me most interesting because it opens out an entirely new line of thought ; in fact—I will be quite frank—there is more in it that I did not understand than that I did. So often in the works, costs or works accounts are looked upon as our dark enemies and it is only by getting our costs put to us in a simple form that we are able to realise what is the aim of these accounts. They are not just to prove to the Board whether they are making a profit or a loss—often by the time they get these figures it is too late. The object to my mind, is to place simple figures before the works manager, such as will enable him to ascertain immediately whether any departure has been made from standard such as, for example, not following the planning laid down or doing work with a different kind of labour or machine from that predicted, or an excessive amount of scrap being produced which requires investigation during the time the order is actually being manufactured in the shop.

One thing occurred to me—that very often we get a man in the shop, a foreman or a rate fixer, coming along and stating that by a slight re-arrangement, he can knock a copper or two off the piecework price. Mr. Walker has proved to us that in many cases this is a fallacy because, by so doing, we have only touched on a very small fraction out of our total costs ; we have not touched on the real item that counts, which is usually the overhead. In many cases we may have increased the overhead to such an extent as to obviate all the saving indicated. Mr. Walker mentioned another thing—that very high overheads could, in fact, set a high standard of efficiency. That is a statement I have heard on two or three occasions but frankly, until to-night, I never grasped the real meaning of it. We have had an extremely instructive lecture and I want you to join me in thanking Mr. Walker very much for coming here to-night and giving us this very able lecture.

SHEFFIELD SECTION FIRST ANNUAL DINNER

MR. P. HOLMES, Section President, was in the chair at the first annual dinner of the Sheffield Section held at the Grand Hotel, Sheffield, on May 1, 1937. A large gathering included many industrial leaders.

MR. A. WILLIAMSON, B.Sc., M.Inst.C.E., who proposed the toast of "The Institution," said that industrial efficiency depended largely on keeping plant up-to-date. It was the production engineers who had to drive the firms to see to that, and their success was largely responsible for Sheffield's present efficiency.

LORD SEMPILL, President of the Institution, responding, said Sheffield had had the courage and foresight to start a local section of the Institution during the great depression. That was characteristic of the spirit of Sheffield. The present was a time of prosperity, but it had its difficulties and problems, particularly with regard to the re-armament programme and the supply of materials. He had the fullest confidence that the country could rely on Sheffield to play its part in overcoming those difficulties.

DR. T. SWINDEN, responding to the toast of "The Guests," proposed by MR. J. H. BARBER, M.I.P.E., M.I.Mech.E., said that they had learnt to look to the production engineer as the best man to get things done. It had been interesting to him to see how the production engineer, untrammelled by tradition, had been able to adopt so successfully new and improved methods.

The toast of "The City and Trades of Sheffield" was proposed by MR. W. C. MACARTNEY. In responding, MR. A. B. WINDER said that he had been associated with the steel makers for thirty years and he was filled with admiration for the way in which the loyalty of the employees had helped towards Sheffield's progress.

Dr. W. H. HATFIELD, F.R.S. proposed "The Sheffield Section," and MR. HOLMES, Section President, in replying said that in the short time since they had started their membership had risen to 50. He paid a tribute to the work of Mr. Clare as Hon. Secretary, and to the great services of Mr. J. G. Young.